G. D. Pollock Esqr

With the author's kind regards
and many thanks

WHAT IS MALARIA?

AND

WHY IS IT MOST INTENSE IN HOT CLIMATES?

AN ENQUIRY INTO

THE NATURE AND CAUSE OF THE SO-CALLED MARSH POISON

WITH REMARKS

ON THE PRINCIPLES TO BE OBSERVED FOR THE PRESERVATION OF HEALTH IN TROPICAL CLIMATES AND MALARIOUS DISTRICTS.

BY

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TO

His Grace

THE DUKE OF ARGYLL, K.T., Etc., Etc.

HER MAJESTY'S SECRETARY OF STATE FOR INDIA

This Work is,

BY HIS GRACE'S PERMISSION, MOST RESPECTFULLY

DEDICATED.

PREFACE.

The opinions expressed in the following pages, upon the origin of malarious fevers,—(a subject of world-wide interest and importance,) differ so materially from those of many men distinguished for scientific attainments and professional eminence, that I should feel much diffidence in publishing them, were they not the result of much reflection, observation, and enquiry, together with considerable experience in my own person of the diseases referred to.

Some remarks of Dr. B. W. Richardson, relating to the connection between meteorology and disease, appear so applicable to the subject treated of in this work, that I cannot do better than repeat his words.

"We observe great outbreaks of disease, and we look for their primary cause: says one, it is 'epidemic influence,' says another, it is 'germs,' 'organic germs;' says a third, it is 'malarious air,' and so on, each having a theory and adding to it some learned reason, or so-called practical inference

or moral; and all omitting to enquire what may be the action, in regard to causation, of common changes of atmosphere combined or uncombined with natural physiological changes in the living organism."

Brought face to face with endemic malarious disease, in all its forms, I found it impossible, under any of the usually accepted theories, to account satisfactorily for many of the phenomena attending its production; I set myself, therefore, to find out something definite as to its nature and origin.

After much careful enquiry, I arrived at the conclusion that malaria, as a specific poison, does not exist.

Further, I became convinced, that the diseases usually attributed to "malarious influence" are caused by chill, or in other words, by the sudden abstraction of heat; and the more closely the circumstances connected with the development of these disorders were enquired into, the more firmly did this conviction become established.

I found, moreover, that the greater prevalence of "malaria" in hot climates, and the graver type of the diseases produced there, could in this way be readily accounted for; together with several phenomena, which are irreconcilable with the usually received theories on the subject.

I am of opinion that many diseases, besides ma-

larious fevers, arise from the cause which I have named; especially dysentery, hepatitis, and others with which these fevers are very closely connected. But to avoid confusion, it may be well to mention, that the term malarious disease is, in the present work, intended to apply only to the intermittent and remittent fevers, of which "malaria" is so generally considered to be the cause.

In conclusion, I take this opportunity to offer my thanks to those friends, who have kindly assisted me with information and otherwise; and especially to Dr. Thomas Inman, who long ago taught me to take nothing for granted, but to observe and to think, to which lesson is mainly due this enquiry into the nature and cause of "Malaria."

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CHAPTER XXI.

WHAT IS MALARIA?

AND

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CHAPTER I.

GENERAL OBSERVATIONS.

What is Malaria?—General ideas on the subject—Hygienic arrangements based on supposed origin of malaria in vegetable decomposition—Correctness of this theory often doubted, but no other has yet supplanted it—Malarious fevers chief cause of sickness over a large portion of the globe—Till nature and origin of malaria fully understood, little can be done to check its destructive effects—Prevalence of malarious disease in India—Mortality directly resulting from malarious fevers bears but a small proportion to that indirectly caused by them—Malarious diseases and their ill effects well known from a very early period, though their origin is still disputed—Malarious fevers those with which the ancient physicians were best acquainted—Hippocrates does not refer to marsh miasma, though aware of the prevalence of disease in marshy places—Probably knew malaria was not a marsh poison—Other ancient writers on the subject—Avicenna alludes to vegetable decomposition—In more modern times Lancisi a great champion of the theory of "marsh poison."—Ascribed malaria to decomposition of animal as well as vegetable matters—Pringle's observations—Opinions of Lind, Annesley, Fergusson, Williams, McKinnon, Morehead, Bennett, Parkes, Martin, Aitken, Salisbury, and Niemeyer.

What is Malaria?

On referring to modern works on Medicine, we find it generally stated, that malaria is a poison given off by organic, especially vegetable matters, in a state of decomposition; and upon this basis are founded the hygienic arrangements of all malarious countries.

Faith in this dogma has many times been shaken, and several authorities have endeavoured to account in other ways for the influence, whatever it be, by which the class of diseases known as malarious fevers is produced; but none of the theories so proposed have stood their ground.

These diseases, not unknown in temperate climates, increase in frequency and intensity, as we approach the tropics;

where they become the most common, and too often the most deadly, enemies of human life.

Constituting, as malarious fevers do, the chief source of sickness and mortality, over a large portion of the earth, it is evident that to discover the cause of a class of diseases so destructive to the human race, is of the highest importance, not only to medicine, but to political economy; for until the nature and origin of malaria are fully understood, little can be done to check its destructive effects.

To form a just idea of the importance of malarious diseases it is necessary to consider not only their influence upon the fate of an army, or the result of a war, of which history furnishes many examples;* but also their powerful effect in checking the spread of the white race, over a large portion of the globe; and even their influence upon the welfare of this country, intimately connected as it is, with every part of the world. There is scarcely a family in Britain but sends forth some of its members to the regions in which these diseases constantly prevail; and where few entirely escape their attacks.

The prevalence of malarious fevers in hot climates may be gathered from the fact, that the last Army Medical Report gives the number of cases of paroxysmal fever alone in British India, during the year 1867, which was unusually healthy, as 19,375 in a force of 56,896 men; equal to one man in three. Not only did this occur in a healthy season, but some of the corps which suffered most were cantoned at the cleanest, driest, and healthiest stations in the plains.

In some instances one corps has suffered much more severely than another, at the same station, and apparently exposed to the same influences.

At Hazareebagh, the A. Battery, 16th Brigade Royal Artillery, had 66 cases of fever amongst 112 men. The 91st Regiment, at the same station, had only 209 cases in an

* In Scinde, every officer and every man, of Sir C. Napier's army of 17000 men, was attacked with fever. In some regiments no surgeon was able to visit the hospitals, and the force was reduced to such a state, that had the hill tribes made a raid, they might have plundered the whole country, as scarcely a man could be found fit for duty. *Administration of Scinde.* p. 72.

average strength of 805. At Saugor, two Batteries of Artillery had 257 cases in an average strength of 201, and the 1st Battalion 7th Regt. had 506 cases amongst 722 men. The head-quarters of the 79th Regt. at Roorkee, one of the healthiest stations in India, had 332 cases in an average strength of 351 ; while the wing of the same Regt. at Delhi, usually not by any means a healthy station, had 248 cases in 299 men. Two Batteries of Artillery at Umballa, generally a very healthy station, had 156 cases in an average of 277 men ; the 94th Regt., at the same station, had 288 cases in a strength of 638 men ; and the 21st Hussars 135 cases in 418 men. At Mean Meer, on a dry, sandy plain, the Artillery, 332 strong, had 155 cases ; and the 106th Regt. in a strength of 768, no less than 1133 cases. At Sealkote, a very healthy station, the 38th Regt. had 554 cases in a strength of 1004; while the 7th Hussars and Artillery, at the same place, had a very small number of cases.* These stations are almost all noted as being amongst the healthiest and best situated in the plains of India; and the sickness did not occur in time of war, or of any unusual exposure.

It must not be supposed that these diseases are confined to the British soldier, and are the result of excesses, as appears to be sometimes imagined ; for though the soldier generally suffers most, the civil population, European and Eurasian, and the natives of the country, suffer severely. In some districts of lower Bengal the sickness and mortality from this class of fevers has for some years past been very great, and last year the native population of a great portion of northern India suffered severely from the same cause.

It is to be borne in mind, in considering the mortality resulting from malarious disease, that the deaths reported as occurring from fevers, bear but a small proportion to those resulting from secondary affections, induced by repeated attacks of these complaints. The number of constitutions irretrievably injured by the same cause, can of course never be known.

Though from the earliest period in the history of Medicine,

* *Army Medical Report*, 1867.

the diseases referred to have been known, and their baneful effect upon the human constitution fully recognised; up to the present time authorities have not been able to agree as to their origin. From the great length at which the ancient physicians treat of the different forms of malarious fever, as well as from the climates in which they lived, there is no doubt that this was the class of fevers with which they were best acquainted.

Hippocrates, in his "Epidemics," alludes constantly to climatic influences in the production of fevers, and describes minutely the changes of the seasons and variations of temperature.

In his "Aphorisms" this writer says: "The changes of the seasons mostly engender disease, and in the seasons, great changes either of heat or of cold, &c." Again he says: "In the seasons when during the same day, there is at one time heat and another time cold, the diseases of autumn may be expected."* It is well known that at the present day, malarious fevers are the chief autumnal diseases, in the countries of which this was written.

It has been observed, as mentioned by Dr. Adams, that Hippocrates does not refer to marsh effluvia as a cause of fevers; he was well aware however that malarious disease was prevalent in marshy places, for he mentions enlarged spleen, emaciation, and dropsy, also dysentery, diarrhœa, and quartan fevers, as prevalent amongst habitual drinkers of marsh water;† who, of course, must have lived in marshy districts. It is therefore most probable that this writer, knowing that malarious fevers were not by any means confined to the neighbourhood of marshes, avoided the error, into which so many have fallen in modern times, of considering the presence of a marsh poison essential to the production of these diseases.

Aretæus notices the connection between marshes and disease of the spleen, and also the influence of the autumnal season.

Galen mentions great heat of the atmosphere as a frequent cause of fevers, he also mentions the exhalations from marshes;

* Sydenham Ed. ii. 3, 715-720. † *Op. Cit.* i. 195.

but though he lays great stress upon the putrefaction of animal substances, as of dead bodies during war, he does not allude to vegetable decomposition as a cause of fevers.*

Paulus Ægineta ascribes fevers generally, to exposure to heat and cold, foul air, fatigue, anxiety, and other depressing causes. Of air he says: that is best which is perfectly pure, such as is not defiled by the exhalations from lakes or marshes, nor from any pit which emits pestilential vapours; and he alludes to the noxious qualities of a canal (sewer) carrying the impurities of a city; but he considers any air unwholesome which is loaded with vapours, and refers to Acron of Agrigentum having arrested a pestilence by kindling a great pile, and so changing the air from a humid state to a dry and hot condition.†

Celsus attributes to great and sudden variations of temperature, the injurious influence of the autumnal season.‡

Avicenna, or Bou Ali Sina as he is called in the East, where he is still considered the highest authority on Medicine, amongst other causes of fevers, mentions the exhalations from water impregnated with decomposing vegetable and other matters; considering that they induced putrefaction of the humours.§

Rhazes, known to the hukeems of India, as Abou Beker Ibn Zecharia, considered putrefaction of the humours to be the cause of fevers, and that this might arise from exposure to climatic vicissitudes, unwholesome food, exhalations from stagnant water, unwholesome air, &c. Air, he says, is rendered unwholesome by great heat, dense vapours from lakes and marshes, foul odours from putrid things or dead bod-

* *De Differentiis Febrium.* Lib. i. Cap. 6. Ed. Kuhn.

† *Paulus Ægineta.* Sydenham Ed. Lib. ii. 273-274.

‡ *De Medicina.* Lib. ii. 1.

§ Et hujusmodi quidem complexio aut generat humorem malum, aut corrumpit id quod generat, propter abbreviationem suam in digestione, et quia movet cum motu pigro, et istæ causæ sunt juvantes in generatione oppilationis generantis putredinem, aut propter dispositiones extrinsecas ex æribus malis, sicut est aër pestilentiæ, et aër (lacunarum et locorum infusorum, in quibus madefiunt res, ut Linum et Asphaltum,) et quandoque aggregatur de eis numerus rerum plurimus, et plurimum causarum putredinis humorum est. *De Feb. Putridis.* Lib. iv. 1. Ed. Venetiæ 1608.

ies, and being shut in amongst ravines, high mountains and sheltered lakes, where the winds cannot reach; and, is wholesome when light and clear, when it does not contain much vapour, and is not stagnant, but is kept in motion by gentle breezes; *and when it does not cool suddenly at sun-set.*"*

Lancisi, the great champion of the "marsh poison," considered that this was engendered by exhalations from stagnant waters impregnated with earthy and saline matters, vegetable debris, the remains of dead animals, and animal and vegetable filth and refuse, stirred up by the heat of the sun.†

Though Lancisi is always quoted in support of the vegetable origin of malaria, it is evident that he, with the older writers, considered animal matters in a state of decomposition at least as necessary to its production, as vegetable substances in the same condition.

Sir John Pringle, in his description of the intermittent and remittent fevers from which the British army suffered severely in the Netherlands and Dutch Brabant, in 1743—1748, says: "The heat and moisture of the air appear to be the chief remote and external cause of these fevers, and this cause is most prevalent, not only in proportion to the warmth and closeness of the weather, but to the quantity of vapour with which the air is loaded, in the drought of summer."‡

Lind in his description of the remittent fever he saw in Bengal in 1762, seems to have felt some difficulty in accounting for it, under the prevailing theories; for while regarding malaria as due to vegetable decomposition, he writes: "Violent heat is a powerful exciting cause of this fever, and from thence many are seized by being exposed to the heat of the sun."

* *Tract.* iii. Chap. xxv.

† Ex iis igitur omnibus partim terrarum, saliumque inquinamentis, partim frascentium vegetabilium, partim animalium cadaveribus, partim denique eorum et insectorum sordibus, exuviisque existit putrida illa congeries, ex qua desides aquæ labem, noxiamque calore solis verberatæ concipiunt, et circumfusum aërem solent inficere. *De Noxiis Paludum Effluviis*, &c. Lib. i. Cap. vi. 28. Ed. 1745.

‡ *On the Diseases of the Army.* Part iii. Cap. iv. 183.

"Sudden cold, in hot marshy countries, is to be reckoned next to the marsh miasmata, as the strongest exciting cause of this disorder; and many are of opinion that cold alone, provided the body is sufficiently predisposed, is sufficient to generate a disorder, perfectly like that which is produced by the marsh miasmata."*

Annesley, writing in 1828, remarks: "There is perhaps no practitioner that is not fully aware that the majority of the most prevalent maladies within the tropics, more particularly the different forms of fever and dysentery, are chiefly owing to the exhalations proceeding from marshy situations, and from vegetable matter in a state of decomposition."†

Ferguson, whose experience in malarious diseases was very great, observes: "The form of fever to which it (malaria) gives rise, rages throughout the world, wherever a marshy surface has been exposed, for a sufficient length of time, to the action of a powerful sun. I have said for a sufficient length of time, because as will presently be seen the marsh must cease to be a marsh, in the common acceptation of the word, and the sensible putrefaction of water and vegetable must be alike impossible before its surface can become deleterions. It will also be seen that a healthy condition of soil, in these pestiferous regions is infallibly regained by the restoration of the marshy surface to its utmost vigour of vegetable growth and decay."

"The previous marshy surface, or rather the previous abundance of water, is however an indispensibly requisite preliminary in all situations to the production and evolvement of the marsh poison."‡

Again, Dr. Williams says: "It seems therefore proved that the deleterions agent is neither heat nor moisture, nor any gas extricated by the marsh, and it follows almost as a necessary consequence that the remote cause of paludal diseases must be a miasm, poison, or malaria, whose presence

* *On the Putrid Remitting Fever in Bengal.* p. 39.

† *On Diseases of India and Tropical Climates.* i. 49.

‡ *On the Nature and History of the Marsh Poison.* Trans. Royal. Soc. Edin. Vol. ix.

is solely detected by its action on the human body. Two hypotheses have been imagined to account for the origin of this poison. The one that it is a product of vegetable decomposition; the other that it is an exhalation from the earth, favoured by the condition of the marsh. Many difficulties beset either of these, but the objections to the hypothesis of vegetable decomposition are far less numerous than to that which considers it as the result of simple terrestrial exhalation."*

Dr. McKinnon, of the Bengal army, unable to reconcile the usual theories on the subject of malaria, with the circumstances under which it often appears, says: "It is very important to enquire whether fevers occurring when there is dry heat, when the atmosphere and soil are both saturated with moisture, and when the process of evaporation is drying up the soil, previously submerged; are all identical in having what is called malaria as their common origin."

"Other views of the question will, I think, lead to the conclusion that if we assign all these fevers to what we call malaria, there must be different kinds of it."†

Dr. Morehead observes: "The presence of malaria is determined by the occurrence of certain derangements of health attributed to its influence, for as yet, all other means of investigation have failed in detecting it."

"A certain degree of heat acting on the earth's surface previously soaked with water, is essential to the production of malaria. It is more certainly generated, while the process of drying is going on—when aeriform emanations exist, in degree proportionate to the rapidity with which the desiccation is effected. Hence malaria is most abundant in marshy grounds, after the quantity of water has been reduced by evaporation to that condition, when the drying of the surface of the ground begins, and while the atmospheric temperature is still high. It is then after the heats of the summer have passed and the autumnal season has set in—

* *On Morbid Poisons.* ii. 425.

† *Indian Ann. Med.* 1856. No. v. p. 133.

the months of September and October—that in marshy countries, malarious fevers chiefly prevail."*

Dr. J. Hughes Bennett observes, that the cause of intermittent fever is found "in all countries which are low, swampy, and humid, and in localities where the ground is marshy and presents a moist alluvial soil, especially in the neighbourhood of extensive woods. We must not suppose however that marshes and moist alluvial soil are the only causes of intermittent, for in India it sometimes prevails in hilly districts, at a considerable elevation, and is known by the name of hill fever. We may therefore conclude with Fergusson that the cause of intermittent is a condition of the atmosphere, occasioned by evaporation from the earth's surface by the solar rays, rather than by currents of air. The frequency of the disease in the autumn months is in favour of this theory."†

Dr. Parkes says the external cause of malarious fevers "is presumed to be putrescent, or at any rate decomposing vegetable matter, derived from a moist and putrescent soil, which is carried into the body by the medium of water or of air."

"The conformation or structural condition, which permits the external cause to act, is evidently not equal in different individuals, or in different races, but we are quite ignorant of its nature. It is not removed by attacks of the disease; but on the contrary, after repeated attacks of ague, a peculiar condition (of the nerves?) is produced, in which the disease can be brought on by causes, such as cold and dietetic errors, which could never have caused it in the first instance."

"The internal predisposition is greatly heightened by poor feeding, anæmia, and probably by scurvy."‡

Sir J. R. Martin appears to favour the opinion, that the origin of malaria may be found to be connected with electricity; and considers that certain geological formations,

* *On Disease in India*, i. 4–5.

† *Clinical Lectures*, p. 951–2, 4th edit.

‡ *Hygiene*, xviii. 474, 475.

especially ferruginous rocks and soils, are intimately connected with its production.*

Dr. W. Aitken remarks: "In these forms of fever, a malarial poison of an unknown kind, generated in paludal regions or littoral districts, is absorbed and affects the blood, as cholera, typhus, and other miasmatic poisons do. The poison in the absence of any better name is known as malaria, and as physicians have merely inferred the existence of such a poison, no exact knowledge has yet been obtained, as to its nature and source. Indeed it still remains to be shown that malaria has a substantial existence."†

Malarious disease has by some writers been ascribed to the development of minute living organisms. Comparatively recently, Dr. Salisbury announced the discovery of the cause of malaria, in certain low forms of algoid vegetation, which flourish in marshy places, but his discoveries have not been confirmed, though some years have elapsed since their first announcement.‡

Professor Felix von Niemeyer has, "no hesitation in saying decidedly, that marsh miasma—malaria—must consist of low vegetable organisms, whose development is chiefly due to the putrefaction of vegetable substances." The Professor admits, however, that "these low organisms have not actually been observed. No one has seen malaria spores."§

That such a variety of opinions should have existed on the subject; and that even late writers, with such an accumulation of evidence as they have before them, should not have been able to arrive at any definite conclusion; show the subject to be a difficult one. The difficulty has no doubt been increased, by so many writers who have had a practical acquaintance with malarious diseases, having described them under such very different circumstances; each drawing his

* *Influence of Tropical Climates*, &c, 19–23.

M. Armand, whose "Algerie Medicale" I regret that I did not meet with until this work was in the printer's hands, rejecting entirely the idea of a specific "marsh poison," ascribes the fevers of Algeria to what he terms thermo-electro-hygrometric influences. *L'Algerie Medicale*, iii. 118.

† *Science and Practice of Medicine*, i. 504, 5th edit.

‡ *New York Journal of Medicine*. Jan. 1866.

§ *Text-book of Practical Medicine*. ii. 609. New York Ed. 1869.

deductions from the phase most familiar to himself, and appearing to ignore tho fact, that others had noticed the same diseases, originating under totally different conditions. If all our information on the subject was derived from Annesley, we must suppose that swamps and forests aro essential to the production of malaria; if from Fergusson we must consider that the poison can only arise in dry and parched districts, from which all moisture has disappeared; yet both writers were acute observers, and practically acquainted with malarious disease; they had met with it however under different circumstances.

In order to understand thoroughly, the nature and cause of malaria, it is necessary to consider all the very varied conditions under which it presents itself, at different seasons, in different climates, and amongst different races.

CHAPTER II.

GEOGRAPHY ETC. OF MALARIA.

Northern and Southern limits of malaria—Focus of malaria in tropics—In Northern Europe, malaria rare except in marshy districts, and on banks of rivers—In the south with a warmer climate, it is found in dry and barren places—In Asia and America the distribution of malaria follows the same laws—In the southern Hemisphere both in New and in Old World similar changes are observed in the distribution of malaria, in proceeding from the south towards the tropics—Intensity of malaria increases with heat of climate—Some countries have been erroneously supposed to be free from malaria—Australia—Ireland—In hot climates, no locality free from malaria—Climatic influence shown, by increased heat being attended with greater prevalence and malignancy of malaria, and by its extension to seasons and situations, which in cooler climates are exempt—Malaria season not always in Autumn, but varies with climate—Where fevers prevail in hot weather, type always severe—In equatorial regions rainy season most malarious and dry season most healthy—In some countries malaria very prevalent in cold weather.

M. Boudin considers that the northern limit of marsh fevers, may be represented by the isothermal line of 5° centigrade (41° F.); he mentions that intermittent fevers are met with near Gefle in Sweden in 60°40 N. lat.; and quotes Waldenstrom, that they sometimes appear much further north.*

The southern limit of malaria is somewhat doubtful, but intermittent fevers are comparatively rare at the Cape of Good Hope, and in the corresponding latitude of south America.

Though the focus of malaria may be said to be within the tropics, as there its presence is felt most constantly and with most deadly effect, it exists over almost the whole of the temperate zones. In Europe from within five or six degrees of the Arctic circle, malaria is to be met with in almost every marshy district, and on the banks of most rivers, especially those liable to inundation; but in the more northern coun-

* *Traité de Geographie et de Statistique Medicales*, ii. 514.

tries it is rarely met with, except in moist situations. In southern Europe, as the heat of the climate increases, malaria begins to show itself in places where no marsh exists. There, tracts of land which, after being flooded, have become perfectly dry and parched are found highly malarious. So also are dry beds of rivers and torrents; and even barren rocks, like Gibraltar and some of the Mediterranean islands.

In America, malaria is found existing under similar conditions. In the north it seldom leaves the neighbourhood of swamps, or the damp and low lying banks of rivers and lakes; but as the heat of the climate increases, on approaching the tropics, the presence of malaria becomes more and more general; and is no longer confined to the neighbourhood of marshes. It even reigns in the parched and arid Llanos. In Asia and also in Africa, the same disposition occurs.

In the southern hemisphere, the same changes are observed, in the distribution, prevalence, and intensity of malaria; in proceeding from the south towards the tropics.

Thus whether in the old or in the new world, as the climate becomes hotter, malaria is found to be less and less limited to particular localities, till as we approach the tropics, we find that no situation is free from it.

Though malaria is to be found throughout the torrid, and over almost the whole of the temperate zones, it is not to be supposed that it exists everywhere in the same degree, or that disease of the same severity, is everywhere produced; the gravity of type being, as a rule, in proportion to the heat of the climate.

In every country, from the equator to within a few degrees of the arctic circle, malarious disease is met with sufficiently often, to show that its cause exists. Some countries have been considered to enjoy a complete immunity from malaria, while its existence in others, in the same latitudes, was undoubted; but this supposed anomaly, has always disappeared before careful enquiry. Thus the existence of malaria in Australia, has been denied, and in the cool dry climate of the south, it is no doubt rare; but as the country

has become better known, and the population has extended towards the north, there is no longer any room to question the existence of malarious disease, even in a very intense form. Some have also disputed the existence of malaria in Ireland, but its occasional presence there is certain.

In hot climates, though its effects are felt much more in some places than in others, owing to local causes, no part of the earth's surface is absolutely free from the influence of malaria; which is to be found in the swamp and in the sandy desert; in the dense forest and the cultivated plain; on the lofty mountain and in the alluvial delta, scarcely raised above the level of the sea; in the fertile valley and amongst bare, sun-baked, rocks; in an atmosphere saturated with moisture and where the air is so hot and dry that no dew is formed, and all vegetation is burnt up.

In cold climates, the prevalence of malaria is in great measure limited to the autumnal season; but in hot countries it exists at all times. Though generally most prevalent in the autumn months; it is so in some places, during the hottest and driest period; while in others, the rainy season is that during which it most prevails. It is often very prevalent even in the coldest months.

The influence of climate, then, upon malaria, is shown by increased heat being attended, not only with a greater prevalence, and greater degree of malignancy, of malarious disease; but also by the appearance of malaria, in seasons during which, in cool regions, it does not prevail, and in situations, that in such regions, are exempt.

Though in hot climates, malaria prevails at all times, it every where shows a preference for some particular season; which is determined by general and local causes, all more or less connected with climatic influences.

In the plains of upper India, malaria though never absent, is most prevalent in autumn, as it is in all countries in which a distinct cold season occurs. The reason of this may be more easily understood, by a comparison of the climatic conditions, prevailing at different periods.

In the large tract of country referred to, Spring, which

begins in February or March, according to the latitude, is as in most countries the pleasantest and healthiest period of the year. Early in the season, the sun at midday may be hot; it always is so towards the close; but the day being too short for the earth to become heated to excess, the nights are cool, and the variation of temperature is moderate.

Vernal fevers however often prevail, especially if rain falls or, if the winter rains have been unusually heavy, for the variations of temperature are then greater; there is however nothing like the universal prevalence of malaria, which is met with in autumn.

The trees at this time, put on their leaves, and the country is covered with green crops.

As the sun acquires more power, and remains longer above the horizon, the weather becomes hotter, the earth is parched, pools of water and marshes dry up, streams vanish, and considerable rivers even, become shallow watercourses. Grass withers and disappears, and the crops are only saved by artificial irrigation.

The hot season has begun. All crops are cut, and no vegetation is to be seen, but the little which struggles for existence in the dried up beds of watercourses or swamps. The face of the country is bare and brown; scorching "hot winds" sweep over it, and little is to be seen but parched earth, and clouds of dust.

Every living being seeks shelter from the fearful heat. Even the crows and sparrows cower in the deepest shade that they can find, with their bills wide open, gasping for breath. So short are the nights and so great is the absorption of heat by the earth, that the loss by nocturnal radiation is not sufficient to cause much *reduction of temperature. No dew is formed,* and the hot winds frequently blow night and day.

At this season, trying though it is to animal and vegetable life, and though the intense heat at night drives people, by sleeping out of doors, or with windows and doors open, to expose themselves much more to night air, than at any other time, malarious fevers are much less prevalent than in Autumn, especially amongst the natives of the country. Cases of ma-

larious disease do occur however, more particularly if the hot season be protracted, or in case of unusual exposure; they are much more common amongst Europeans than amongst the natives of the country, and are often of very severe type. Why these results follow a protracted hot season, will be explained hereafter.

After three or four months of this intense heat, clouds appear; then comes the rain, which at first seems to disappear as soon it touches the ground, so greedily is it taken up by the thirsty soil. All then becomes fresh and green; ground, which a short time before rang like metal under a horse's hoofs, is covered with vegetation, and crops spring up as if by magic. The soil is everywhere saturated with moisture, and so is the atmosphere.

During the rains malaria is always present, but to a much less extent than in Autumn; fevers however sometimes prevail in epidemic form.

At last the downpour ceases, clouds disappear, the sun shines forth, and the heat though less intense than before, is during the day oppressive and stifling. But no sooner does the sun go down, than the temperature falls rapidly, condensation of moisture takes place, mist and copious dew result, and the nights are damp and chill. This is the time when malaria is at its worst, and the population of whole districts is prostrated by fever.

Once more the sun gradually loses its power. The heat by day abates. The quantity of moisture both in soil and atmosphere diminishes. The difference between daily and nightly temperatures becomes less and less; and the cold season arrives, to brace and invigorate those, who are sufficiently well clad and housed not to feel its prejudicial influence. This is the time in which we, natives of a Northern climate, rejoice; to us who are well clothed, have good dwellings, and thoroughly understand how to protect ourselves from chill, the cold season is delightful. But to the natives of India and especially to the poorer class, who have not the means of providing against the bitter cold at night, this period is almost as fatal as the worst part of Autumn; intermittent and

remittent fevers, with thoracic and abdominal complications, often becoming epidemic amongst them.

In the lower ranges of the Himalayah, as in the plains, the Autumnal season is the most unhealthy; but at greater elevations, from about 4000 feet upwards, malaria is most prevalent in the rainy season. When the mountains are wrapped in clouds, and the air is saturated with moisture; when in the driest house, boots become mouldy, and clothes and bedding hopelessly damp; then fevers and dysentery prevail, and thinly-clad natives, from the plains, are prostrated in numbers. The hill people do not suffer to anything like the same extent, but they are comparatively well clad, generally in woollens; and are moreover accustomed to a colder climate. This also applies to European travellers, or residents in the hills; though neither they, nor the hill men, invariably escape the diseases referred to.

Amongst the hill ranges and on the table lands of Southern India, malaria is often most deadly in the hottest and driest season; and I may observe in passing, that in all countries, where fevers prevail in the hot season, they are of very severe type.

In Algiers the rains occur in the winter, from the middle of December to the middle of March; spring, therefore, is the season in which the drying process goes on most actively in the soil. Yet the spring in Algiers is very healthy; the climate is mild, and as M. Haspel observes, the sanitary state of the garrison attests the salubrity of the air. As the heat increases, the soil dries up, the harvest is gathered in, and by the middle of June the heat becomes intense, vegetation disappears, and "the country puts on the aspect of the desert." Then fevers become very prevalent, and assume everywhere the remittent and pseudo-continued forms, with dangerous abdominal and cerebral complications.*

The vast, heated surface of the Sahara keeping up an ascending column of air; to restore the equilibrium, a north wind, loaded with moisture from the Mediterranean, blows over

* *Maladies de l'Algerie*, Tom. i. 18—22. Tom. ii. 165.

Algeria; so that throughout the hot season in that country, the dews are copious and the nights are very damp.

"Dews," says Pietra Santa, "are common in the hot season, and very abundant during the extreme heats."*

In the oases of the Sahara, as in Algiers, fevers prevail both in the hot season and in Autumn.†

In Ceylon, as in most equatorial countries, malaria is most intense in the rainy season. The month of May, when "the burst of the monsoon" takes place, is the most unhealthy.

In Java, and the Malayan Archipelago, the rainy, is also the sickly, season.

Wallace says of New Guinea: "The weather was terribly wet; and fevers, colds, and dysentery, were continually attacking us."‡

Again, at Gilolo, he observes: "It was now wet, squally weather, and there appeared a stagnation of insect life. We stayed five days, during which time, twelve people died in the village, mostly from simple intermittent fever."§

In equatorial America, the rainy season is the most malarious.

Humboldt alludes to the epidemic fevers that, on the Orinoco, "prevail with violence at the entrance of the rainy season."‖ In the mangrove swamps of Central America, the months of June, July, and part of August are the most unhealthy; and they are also the most rainy. In August the rains cease. The most healthy months are January, February, March, and April, which are also the driest. March and April are the hottest months.¶

On the coasts of tropical Africa, the rainy season is the most deadly.

Lind observes of the Guinea coast: "This, as most tropical countries, has properly speaking only two seasons, the

* *Climat de l'Algerie*, 14.
† Tristam, *Travels in the Sahara*, 288.
‡ *Malayan Archipelago*, xxxiv. 323.
§ *Ibid.* xxxvii. 380.
‖ *Narrative of Travel*, xx. 234. Ed. Bohn.
¶ Capt. B. Pim, R N., *Gate of the Pacific*. 70.

wet and the dry; the former is commonly of about four months continuance and is the season of sickness."*

"Within this range," says Dr. Horton, "we meet with the most unhealthy periods of the tropical year, the commencement of the rains and their termination."† The same writer adds: "The months of February, March, and April, although the hottest in the year, especially in the Gambia region, are the most healthy."*

Barth mentions that, the season of damp, chilly, and foggy weather is called by the Tuarek tribes of the interior of Africa, "the black nights."‡ And Livingstone says that in the country near Loanda, the wet season, when the air is full of moisture, is so deadly to the natives, that it is called by the Portuguese the "carneirado," "as if by disease they were slaughtered like sheep."§

In many countries malarious disease is very prevalent in the cold season.

In the elevated region of Central Africa, Livingstone found malarious fever very prevalent amongst the negroes in the "middle of winter," when the temperature of water in the morning was 47° and that of the air 50°, "which being loaded with moisture was very cold to the feelings."‖

I have already alluded to the prevalence of fevers amongst the natives of India in the cold season. In the Punjab last year, the sickness from this cause was very great, at a time when the thermometer at night fell several degrees below freezing point.

In Mysore and some other districts of Southern India, intermittent and remittent fevers prevail during the months of November, December, January and February, which the inhabitants attribute to cold north-easterly winds.¶

It appears then, that the cause of malarious disease exists in almost every part of the habitable globe:—

* *On the Preservation of Health of Europeans in Hot Climates*, ii. 50.
† *Climate and Meteorology of W. Coast of Africa*, 217, 218.
‡ *Travels*, v. 49.
§ *Travels in Southern Africa*, 418.
‖ *Ibid.* 483.
¶ *Madras Topographical Reports*, 1844.

That in cold countries it prevails only in low and swampy spots; but, as the heat of the climate increases, it becomes more generally distributed:—

That, though malarious disease may prevail at any season; in those countries in which winter occurs, it is most prevalent in autumn; while, where there is no winter, the rainy season is that in which it becomes general.

CHAPTER III.

VARIOUS THEORIES CONSIDERED.

Theory ascribing malaria to decomposition of organic matter has had most supporters in Modern Times—Ancient physicians attributed the unhealthiness of marshy places chiefly to unwholesome water or to damp, foggy air—Avicenna appears first to have ascribed noxious qualities to decomposing vegetable matter such as flax—But ascribed same properties to bitumen—Lancisi quotes Avicenna as his chief authority—Controversy on subject of flax steeping—Observation that malaria may exist without a marsh caused a modification of this theory, ascribing it to organic matters in the soil—On same basis late writers advocate theory which ascribes malaria to drinking water—Prevalence of malaria in marshy places led to the idea that malaria was a marsh poison—Swampy districts generally abounding with luxuriant vegetation, this from association became considered the cause of malaria—To this day "rank vegetation" exterminated by sanitarians with little result—Some marshes almost entirely free from malaria—Bogs of Ireland—Singapore—Amazon valley—If malaria caused by vegetable decomposition, why are these exempt?—In hot and swampy equatorial countries, the healthiest period is when banks of rivers and lagoons are most exposed, and the most unhealthy season, when they are covered with water—When the Thames was comparatively pure agues were rife in London, but when the river was most foul they were almost unknown—Mangrove swamps—Humboldt's experiments—Livingstone's experience—If malaria be caused by any product of vegetable decomposition those most exposed to such products should be most frequently affected by them—Is this the case?—Tanners not more liable to ague than other people—When refuse bark laid down in streets, ague not produced—Market gardeners—Farmyards and stableyards—Steeping of Sunn or Indian hemp—Indigo refuse—Preparation of flax in north of Ireland—Preparation of hemp and flax supposed to produce malaria, but malaria due to locality—In some cases those living near a swamp escape malarious disease—Jail at Goojrat—Author's experiment.

Of the various causes, to which writers on the subject of malaria have ascribed its origin, the chief are:—

1. Exhalations from decomposing organic, especially vegetable matter, in water or in soil.

2. The drinking of water, impregnated with similar matters.

3. Electrical action, combined or not, with certain geological formations.

4. Certain gases.

5. The invasion of the body, by certain low forms of organic life.

6. Climatic influences.

Let us consider these supposed sources of malaria, and endeavour to ascertain in which of them, if in any, malarious disease takes its origin.

Of all the theories which have been proposed to account for the origin of what is called malaria, that which ascribes it to the decomposition of organic, and especially vegetable matter has been most popular in modern times; and though it has been questioned by several authorities, it is still adhered to with more or less tenacity, by most writers on the subject. We have seen that the ancient physicians considered the neighbourhood of swamps unwholesome, and knew, that the residents in such places were subject to fevers, and affections of the spleen and liver.

Although however they frequently allude to the bad effects of marsh air, it seems almost certain that the early Greek and Roman writers did not recognize the exhalations from decomposing vegetation, as a cause of these effects; but attributed them mainly to the damp, raw, foggy, atmosphere. Hippocrates, as I have already mentioned, dwells especially upon the bad effects of drinking the fœtid, stagnant water of marshes, mentioning that those in the habit of doing so, were subject to fevers, diseases of the spleen, and other consequences, which we know to arise from residence in such places; other writers do not lay the same stress upon the unwholesomeness of the water, but dwell more particularly upon the bad consequences produced by the air of swamps. Almost all these mention fogs or mists, as containing the noxious principle.

Avicenna appears to be the first of the old physicians, in whose writings is a distinct allusion, to the noxious effects of exhalations from water impregnated with decomposing vegetable matters, such as flax; but as he ascribes the same properties to water impregnated with bitumen, it is probable that the fœtid smell, rather than any actual experience of disease resulting from it, led him to express this opinion

upon the effects of steeping flax; which has led to so much controversy during successive ages.

In the works of almost all writers after Avicenna, the steeping of flax is referred to, each no doubt taking his cue from that writer; upon whose works in fact, for a long period, most medical treatises were mere commentaries.

Lancisi quotes Avicenna as his great authority, for the noxious influence of exhalations from decomposing vegetable matters, especially of flax and hemp; he also quotes Magnetus to the effect, that in England the steeping of flax and hemp was forbidden under heavy penalties, in springs, ponds, or any public reservoir, or where cattle, sheep, &c. were watered.*

Similar laws were in force, about the same period, in Holland and in France.

The defilement of the water, by the rotting flax, appears however to have been as much dreaded, as the poisoning of the air by exhalations given off from it.

It does not appear, that the belief in the noxious effects of decomposing vegetable matter, was even then universal, for Lancisi mentions a great controversy on the subject, and admits that several physicians denied any such effects; he quotes especially P. Pereda, who said, that in many cities of Spain, near which hemp and flax were grown and prepared, the people enjoyed health and long life.*

In answer to Gometius Pereira, Lancisi admits that the steeping of hemp and flax in running water, does not produce bad effects;* and he enters into a long and by no means lucid explanation, as to why the exhalations should then be harmless, which in the case of stagnant water are so hurtful.

The observation, that malaria may exist where marshes do not, gave rise to the modification of this theory, which ascribes malarious fevers to the decomposition of some organic matter in the soil, developed by heat and moisture.

The doctrine which attributes these diseases to the drinking of stagnant water, impregnated with decomposed vegetable matter, rests of course upon the same foundation as the

* *De Noxiis Palud. Effluviis*, Lib. i. p. 1. cap. viii. 34.

preceding; the advocates of each assuming the cause of malaria to be the decomposition of organic substances.

We may now examine how far this theory is borne out by facts.

That malarious fevers frequently prevail in marshy places, requires no demonstration. To enumerate the swampy districts, in which these diseases abound, would be impossible. The fens of our own country, the low, wet flats of Holland, the moist plains of Hungary and Lombardy, the Maremma, and Roman Campagna, are well known as favourite haunts of "paludal" fevers. Damp spots, however, in which malaria lurks, are to be found in every country in Europe, and in almost every part of the world.

It was this connection of malaria with marshes, observed so constantly in the countries, with which so many writers on this subject were best acquainted, which led to the very general idea that malaria is a paludal poison, generated in quagmires, and unable to exist except in swampy places. Upon this idea, nearly all the theories connected with the so-called "paludal miasma" have been based.

Even the most recent theory on the subject of malaria, ascribes it to the effects of certain low vegetable organisms, which can only exist in marshy places.

Moist districts, in general, favour the growth of a luxuriant vegetation, and this, from its association with the marsh, became looked upon as the cause of "malaria." To this day even, all "rank vegetation" is mercilessly exterminated by energetic sanitarians; under the vain idea, that in doing so, they are removing the noxious properties of the swamp. How vain the idea is, we shall see presently. Admitting fully, the general preference of malaria for marshy localities, it must be observed, that some of these are free from malaria, or nearly so; though abounding with luxuriant vegetation, and differing, in this respect, in no important degree, from other marshy districts, in the same latitudes, in which malarious disease is very prevalent.

The bogs of Ireland, for example, have long been a puzzle to writers on "paludal poison."

There is no doubt that these bogs consist, for the most part, of decomposed vegetable matter; that they are covered with various forms of marsh vegetation; and that they present all the most prominent features of swamps: yet the people of the country suffer little from malarious disease.

Some writers have indeed affirmed that malaria is unknown in Ireland; but that is not strictly the case. Popham, in his paper on the climate and diseases of the city of Cork, mentions that the name—Cork was derived from Corkagh a morass, and adds: "This unpromising locality was, as might be expected, very subject to intermittent fever."*

I have been assured by one of the most distinguished physicians in Dublin, that in low marshy places on the east coast, ague still occasionally prevails, though in the west it is rare, either on bog or grass-lands; that in some years, however, it is more general; and that in 1829—30 especially, the hospitals were full of "intermittent."

Again, the settlement of Singapore is only between 25 and 35 feet above the sea level, and the adjacent country is still less. Everywhere vegetation is profuse. The open sea is more than a mile distant, though "tidal swamps extend to the station." The neighbouring low ground is much over-flowed at every spring tide. "There is little or no broken ground except the tidal swamps, which do not appear to have any prejudicial effect upon health." Gardens abound, and hedges are in many places much too high to admit of free ventilation. The temperature is not raised by reflected heat, but is daily moderated by a gentle breeze. The hills near consist of clay, with laterite and sand. In the plain the soil is vegetable mould, with subsoil of blue clay mixed with shells and coral. Water is found at a depth of a few feet at all seasons.†

Here then in abundance, are all conditions supposed to produce malaria;—heat, moisture, salt marshes, rich soil, and profuse vegetation; if these produce the "paludal poison," the settlement should be a hot-bed of disease: but it

* *Dublin Journal of Med. Science*, May, 1853.

† *Report of Royal Commission on Sanitary State of Army in India*, ii. 594.

is not so. The official report states; that, "the station and district are healthy to a marked degree."*

To take an instance in another part of the world. The country bordering upon the great river Amazon, situated almost immediately under the equator, is, for the most part, low and flat; it is covered with primeval forest, and the densest tropical growths. Yet, though the banks of neighbouring rivers, under similar circumstances of moisture and vegetation, abound with most deadly malaria, the banks of the Amazon are almost free from it.

Humboldt alludes to this remarkable fact,* and Bates, one of the most recent travellers in those regions, confirms him in every respect.‡

If malarious disease be caused by luxuriant vegetation, rich soil, or by any poison generated from vegetable decomposition, why should the localities just named be almost exempt from it? How could they possibly be so?

By way of contrast to these, I may quote an instance of a different kind.

Everyone knows that a great part of the unhealthy west coast of Africa is low and marshy, intersected by numerous rivers with oozy banks, and covered with rank and luxuriant vegetation; and it has been supposed, that the deadly character of the climate is owing to these conditions: yet situations in which they do not exist, may be almost equally deadly, with those in which they do. Thus, the islands of De Los, in the open sea, 60 miles north of Sierra Leone, are described by Staff-Surgeon Gore, as consisting "of a bed of granite with very little vegetation on the surface." Yet here, in 1825, the mortality in the garrison, from malarious disease, was one in seven; and in the following year, out of 108 men, 48 died and 50 were invalided. The post was then abandoned.§

The greater activity of malaria, often observed when

* *Report of Royal Commission on Sanitary State of Army in India*, ii. 594.
† *Narrative of Travel*, xxi. 314, 315.
‡ *Naturalist on the Amazons*, ix. 251. 2nd edit.
§ *Army Medical Report*, 1867.

marshes are drying up, has been ascribed to the quantity of decaying vegetable and other organic substances, then exposed to the air and sun. But this can scarcely be the reason, for as I have already shown, in those swampy countries, lying nearly under the equator, the healthiest period is the hot and comparatively dry season, when the rivers and lagoons are lowest; when the largest surfaces of fœtid mud, loaded with decomposing matter, are exposed to the rays of a vertical sun. The most unhealthy season, on the other hand, is that in which vegetable life is most active, and when the muddy banks of those rivers and lagoons are covered with water.

Upwards of two centuries ago, when the river Thames must have been comparatively pure, agues were rife in London; Sydenham mentions them in 1678 as amongst the most prevalent and most destructive diseases, whole families being carried off by them;* though even then, they were less prevalent than they had once been. From that time, the quantity of putrefying organic matter, animal and vegetable, in the water, and exposed at ebb-tide on the banks of the river, increased till in 1858-9 the stench from it became unendurable. Yet malaria, under the influence of drainage and the constantly increasing area of the metropolis, has steadily diminished, with the increase of organic matters in the river; and when the fœtid exhalations were at their worst, agues were all but unknown.

Every one has heard of the deadly emanations from mangrove swamps, ascribed by many writers to the mangrove bushes, which are represented as exhaling poison, somewhat as the upas tree was said to do, in days gone by; the exhalations in each case, being probably of the same nature, and the bushes and the trees alike innocent.

Humboldt tried a series of experiments upon the mangrove, "imitating throughout the action of nature in the swamp," but he was unable to produce any poison whatever thereby, and was not attacked by fever, during his experiments.†

* Sydenham, vol. ii. 9. † *Narrative of Travel*, &c., xi. 372. Ed. Bohn.

Livingstone says: "We did not suffer more from fever in the mangrove swamps, where we inhaled so much of the heavy mousey smell, that it was distinguishable in the odour of our shirts and flannels, than we did elsewhere."*

If we allow that the exhalations from putrefying vegetable matter, are capable of producing malaria, it is natural to expect, that those whose occupation requires them to pass their lives, in the midst of such exhalations, must be particularly liable to malarious disease; let us enquire therefore, if this is found to be the case.

Of all trades, tanners are perhaps most exposed to emanations from decaying organic matters, both animal and vegetable; yet these men are not more subject to malarious fevers than other people; nor, when the refuse bark from a tan-yard, is laid down in our streets, to deaden the noise of passing vehicles, are the neighbours attacked with ague.

Market gardeners pass their lives, in the midst of vegetable matters in every stage of growth and decay; yet they are not subject to paludal fevers; although Dr. Eliotson considered, that ague might be contracted by simply passing through a market.

In every farm or stable yard in the country, we may see a mass of decomposing organic matter; in the shape of a huge dung-hill, consisting chiefly of refuse straw and dung, yet a farm yard is considered rather a healthy place than otherwise; whilst farmers and stablemen are certainly not more subject to malarious fevers than other people.

In India, the place of hemp is taken by the "sunn" plant, of which large quantities are grown in the Punjab. The fibre is prepared in the same way as hemp, and the plant is macerated, in the nearest available piece of water; yet malaria is never known to result from the practice. Near the Ravee immense quantities of sunn are grown, and the whole crop is soaked for some 15 days, in the shallow pools left in the bed of the river, at that time containing but little water. The people, at this period, live surrounded by the rotting vegetable matter, yet no outbreak of fever has been known to result.

* *Expedition to the Zambesi*, xxviii. 575.

Dr. McKinnon, who was long stationed in the indigo districts of Bengal, says, of the immense masses of vegetable refuse accumulated about indigo factories: "The amount of decomposing matter, in all stages of decay; now swamped with rain, next day exposed to a blazing sun, is immense; yet after much enquiry, I have never discovered, that fever has been the consequence; though hundreds, nay thousands, are for months of each manufacturing season, exposed to this disagreable effluvium."*

I have made particular enquiries in the north of Ireland, where flax is prepared in very large quantities, as to whether malaria is produced during the process; and I find, that though the effluvium from the rotting material, both while soaking and while drying, is horribly offensive, malarious disease is unknown amongst the work people, or the residents in the neighbourhood.

The prevalence of malaria in places, where the preparation of hemp and flax was carried on, has always been one of the strongest arguments in favour of the origin of marsh poison in vegetable decomposition.

It is evident from the instances just given, that the vegetable matter could not have been in fault; but if we reflect that the process of maceration must, for the sake of abundance of water, often be carried on in low, damp, marshy localities, the natural haunts of "malaria," it becomes easy to understand how the preparation of these useful commodities, should have been so long, and so unjustly, accused of producing malarious disease.

As it is clear that malaria cannot be the product of decomposing vegetable matter, some other cause must exist in marshes, and in other places in which it is produced.

I have already mentioned that some marshy localities are almost entirely exempt from malaria. Not only is this the case however, but it is possible for people to live close to swamps, which have no such healthy character, and yet escape malarious disease.

The jail at Goojrat in the Punjab, having been washed

* *Indian Ann. Med.* 1856, No. v. 138.

away by a flood, an old "serai" was used as a prison. This was an irregular quadrangle, enclosed by a brick wall, ten feet high, round the inside of which, was a sort of cloister, converted, by means of wooden gratings, into barracks for the prisoners. Owing to the intense heat of these quarters the prisoners slept in the open air, except in the cold season, or when it was raining.

During the rainy months, the walls of the enclosure were all but washed by an inundation, on the subsidence of which, the swampy ground was separated from the jail only by a roadway; whilst numerous large pools of putrid, stagnant, water, gave off under an August sun, most offensive effluvia.

Here, according to theory, fever should have been epidemic. Yet during the year 1868, in an average daily strength of 300 prisoners, there were but twenty cases of fever, all of a mild type; and of these, three occurred during the cold season. The mortality was indeed lower than in almost any other jail in India; only one death occurred, and that was of an old man of seventy, from bronchitis.

Thus, a considerable number of men, living on the edge of a swamp, exposed night and day to the exhalations from fœtid mud and stagnant water, teeming with organic matter, remained almost entirely free from malarious disease. The jail in fact was one of the very healthiest in India.

This healthy state of the prisoners was not owing to any absence of "malaria," for the jail guard of military police suffered severely from fever.

The only precautions taken, were to carefully protect the prisoners from wet and cold, and, as far as possible, from exposure to the sun in the hot season.

In 1861 I was stationed at Googaira in the Punjab, in a district covered for the most part with jungle, and lying between the rivers Ravee and Sutledge; the inundations from which rivers, spread yearly over the low lands. When this took place, the station which was on a slightly rising ground, a few feet above the surrounding country, and some two miles from the Ravee, was almost entirely surrounded

by water. In the months of July and August, the heat was intense, and the water, which was from a few inches to some feet deep, in the jungles around, became putrid, stinking, and covered with a thick green scum of low vegetable forms. The atmosphere during the day was like that of a vapour bath, and at night was dank and clammy.

Here I thought, was a favourable opportunity for testing the properties of marsh miasmata; and to do so, I slept at night, through about four months of the hot, rainy, and autumnal seasons, in the open air, less than two feet above the ground, and fully exposed to any exhalations. When rain was actually falling, I retreated into the house, but kept all the doors open. During this period I took no quinine or other febrifuge; my only precaution, being the provision of sufficient bedding to preclude all possibility of chill. In the morning I could often shake the dew off my blanket.

I was gratified to find that I did not take fever, nor had I an attack from that time till eight years afterwards, when in London.

As during the year previous to this experiment, I had suffered from several attacks of intermittent, there could in my case have been no want of susceptibility to "malarious influence."

It is not to be supposed that an experiment of this kind can be decisive, but it certainly may be allowed to form a link in the chain of evidence, against the existence of a specific marsh poison.

CHAPTER IV.

The connection between the forest and malaria—Decomposition of vegetable matter supposed to be the cause of malaria in forests—Connection between malaria and the forest not more constant than between malaria and the marsh—Clearing of forests has sometimes been attended with disappearance or diminution of malaria—But malaria does not always disappear with the woods, and exists where trees do not—Some forests highly malarious, others free from malaria, though vegetable decay occurs in each—Malarious forests generally wet and healthy forests generally dry—Malaria prevails in the swampy forest, under the same conditions as in the marsh—As malaria is found where there is no marsh, so it prevails in some forests which are not swampy—In marshy ground forests retain dampness of soil—In damp situations only, does any benefit arise from clearing forest or jungle—Trees in themselves, harmless in temperate and highly beneficial in hot climates—Belts of trees said to arrest malaria and planting suggested as a means of rendering swamps healthy—Trees in the Soonderbuns, Terai, or forests of Orinoco do not produce any such effect—Trees will not render a marsh healthy, nor a well-drained country unhealthy—Even swampy forests not all equally malarious—Why this difference?—Trees have been supposed to attract malaria—Morehead's remarks—Safest place at night in a malarious country, is in a tree or under it—Natives of India and other countries spend their nights under trees—So also do animals in all countries—Large spreading trees objects of veneration and the planting of trees in halting places an act of piety—In a swampy district, largest trees generally on driest ground—Trees radiate heat slowly, and diminish variations of temperature—The warmest place at night under a tree.

Malarious disease occurs in forests, and is there of course ascribed to the decay of fallen leaves, &c.; the conjunction of the two circumstances being pointed to, as a convincing proof of what may be called the vegetable origin of "malaria." This indeed it would be, if malaria was found in all woods, and never met with where decomposing vegetation did not exist. The connection between malaria and the forest, is however no more constant, than that between malaria and the marsh. Certainly, there are forest tracts in which malarious disease is prevalent, and other regions which, known to have been once highly malarious, have since the disappearance of the woods become healthy.

This result has however, always been attended with a drying of the soil, though not necessarily with any diminution of the organic matter contained in it.

In England, this drying of the soil, which has followed the clearing of forests and the extension of drainage, has all but banished malaria.

In North America, a similar result, though not to the same extent, has followed the disappearance of woods.

In India, the parts of the Terai which have been cleared have been healthier in proportion as they have become drier; and what little jungle is now left, at the foot of the Punjab portion of the Himalayah, is as healthy as any part of the neighbouring country, and as dry.

In Southern India, the conversion to a large extent of jungle land into coffee plantations has rendered many places habitable, which once were considered deadly; it has also diminished the water supply.

Although, in every part of the world, instances occur of forest tracts becoming comparatively healthy, when freed from wood; malaria does not always disappear with the trees.

Thus, "fever and ague" is common enough in many well-cleared districts in North America. In India, malaria has never entirely disappeared from any spot, however thoroughly the jungle may have been removed from its vicinity. An instance of this is seen near Vizianagram, in lat. 18° 20′; where there are numerous ranges of hills, connected with the Eastern Ghats, in the vicinity of which fever is always prevalent. These hills were formerly covered with trees, but are now bare; there being only a few detached patches of underwood to be seen.*

Here, the destruction of the woods has not banished malaria, which still haunts the bare and rocky hills.

It is observable, that while in some forests the most deadly fevers prevail, others, in which vegetable matters must go through the same processes of life, death, and decay, are almost, some even entirely, free from them. Malaria is not unknown in England, yet it does not take up its abode in our well-drained woods and shrubberies, though their soil is a mass of decomposed and decomposing vegetable matter; nor does a day's pheasant shooting involve an attack of ague.

* *Madras Topographical Reports.* 1844.

On the continent of Europe, as also in Canada, Australia, New Zealand, and other countries, there are many large tracts of woodland wherein malaria is rarely developed; but which are in no way free from organic decay.

The forest-clad slopes of the upper Himalayah are as healthy as any part of the range, while the forest tract at its foot is pestilential. Yet the soil of each consists largely of vegetable debris, and in each case is exposed to sun and rain.

Whilst the Terai, Soonderbuns, and many other wooded districts throughout India, abound with the most deadly malaria; large tracts of forest land, in the Punjab, are as healthy as any part of the neighbouring plains; and the pastoral tribes who inhabit them, at all seasons, are amongst the finest races in India; or even in Asia.

These Punjab jungles, to be sure, differ considerably in some respects, from the Terai and Soonderbuns; though in each instance the vegetation is luxuriant in the rainy season, and its decay is equally inevitable. In the former case, however, the ground is elevated, water runs off readily, and the drought for a great part of the year is excessive; while in the latter, the soil is generally swampy to a degree.

The Terai is a shallow valley, or rather depression of the soil, extending along the foot of the Himalayah, in some places many miles in width; it is covered with thick wood, or with tall rank grass; and abounds with extensive swamps. During the rainy season, and for some time after, the whole tract is one vast morass.

The Soonderbuns, which form a portion of the delta of the Ganges, are but little raised above the sea level, they are intersected by innumerable channels communicating with the different mouths of that river, and are covered for the most part with dense forest. Many other highly malarious jungle tracts, in India and in other countries, are excessively swampy.

Malaria prevails in swampy forests under the same conditions as in marshes, and as these when drained become comparatively salubrious, so, in most cases, do forests when their soil is no longer wet.

A most striking characteristic, both of marshes and of forests in which malaria abounds, is the damp and chilly atmosphere at night.

In temperate climates, on ground sufficiently high for thorough drainage, woods are free from malaria; and though fever prevails, in hot countries, in some jungles which are not wet; it is, there, equally deadly in open situations where there is no marsh.

In swampy ground, large forests, by interfering with the action of sun and wind, retard the drying process and so keep up the dampness of the soil. In such places, it is often found that clearing the woods diminishes or drives away the malaria, by allowing the ground to dry. In no other case, does any benefit arise from the destruction of forest or jungle.

Trees, in themselves, are harmless in temperate climates, and are highly beneficial in the tropics, where they tend to moderate the intense heat, by sheltering the ground from the rays of the sun, and where they constantly supply the place of house or tent, to the weary or benighted traveller. Other forms of vegetation are equally innocent.

Many cases have been cited, to prove that belts of wood have been sufficient to arrest the course of malaria; and it has been suggested that, by an extensive system of planting, swamps, moors, fens, and marshes, may be rendered salubrious.* The trees in the forests of Burmah, the Soonderbuns, the Terai, or the forests of the Orinoco, do not however seem to produce any such effect.

The fact is, that trees and shrubs, alone, will not render a marsh healthy, nor will they make a well-drained country unhealthy. The cause of malaria lies far beyond the trees.

But wet forests, like marshes, are not all equally malarious.

In South America, as already mentioned, although the humid and wooded banks of the Orinoco, Magdalena, and other rivers, abound with the most intense malaria; the equally swampy banks of the Amazon, clothed with the great-

* Pickford's *Hygiene*, 185.

est mass of primeval forest in the world, are comparatively free from it.

If decaying vegetation causes malaria, to what is this difference due? The soil on the banks of the Amazon is not supposed to have any antiseptic properties. There is no want of heat or moisture, nor of any of the accessories usually considered necessary for the development of "marsh poison;" and certainly no want of organic matter, living, dying, or dead.

Many have supposed that trees attract malaria,* and even so late a writer as Dr. Morehead observes:—"It is attracted by the foliage of trees, and thus accumulates around them, and between them and the ground."†

Far, however, from this being really the case, the safest place at night, in a malarious district, is in a tree or at the foot of it. The natives of India and the people of other hot countries, on their journeys even at the most malarious seasons, always sleep, if possible, at the foot of a tree. In the forests of South America, both natives and travellers sleep in hammocks slung to branches of trees.

Animals, too, whether wild or domestic, almost invariably pass the night under trees, and this, when no shelter is necessary from rain or wind. In fact, so little reason is there for the supposition that malaria is attracted by foliage, that European travellers in India, whenever they can do so, pitch their tents in a grove.

Large spreading trees are objects of veneration in all wild countries, and the shelter and protection they afford, no doubt, gave rise to the feeling. In India the Banyan, the Peepul, and the Cotton tree, are considered sacred, and are planted, as an act of piety, near wells, and in places where travellers halt at night.

In Africa, as Livingstone tells us, the Banyan is everywhere venerated, and is considered to be a protection from evil;‡ while, in the West Indies, the negroes dread to cut

* Fergusson, *Nature and History of the Marsh Poison. Trans. Roy. Soc. Edin.* vol. ix.

† *On Disease in India*, i. 6.

‡ *Travels in Southern Africa*, 495.

down the Ceiba, as they believe it to be under the protection of the spirits.

Trees in general do not thrive in ground which remains saturated with moisture; in a swampy district therefore, the largest trees are generally found to occupy the highest and driest spots. Again, trees and plants radiate heat slowly, except from the outer surface of their foliage; while they act very powerfully in checking radiation from the ground; consequently, after sunset, the warmest place is under the thickest foliage. This is a matter of the greatest moment to travellers obliged to sleep in the open air, on a damp and chilly autumnal night; and the fact serves to explain how trees are, in some cases, a protection against malaria.

In a hot climate, during the early part of the night, and especially in a dry locality, the sensation of heat in a grove is sometimes oppressive, from the slowness with which radiation takes place.

CHAPTER V.

MALARIA WITHOUT VEGETATION OR STAGNANT WATER.

Malaria sometimes very intense in damp places, though vegetation or surface water is absent—Coasts of Holland—Flats of Brabant—Wilmington—In hot climates malarious fevers prevail in arid places and during great drought—Hennen's and Morehead's observations—Fergusson's cases in the Peninsula—Severe malarious fever in Abyssinia, amongst troops encamped in dry bed of torrent—Mortality amongst horses at same time—Humboldt's observations on malaria in Llanos—The Sahara—Mean Meer in the Punjab—Desert of Rajpootana—Jacobabad in Scinde—Malaria amid barren rocks and hills—Gibraltar—Ionian islands—China—Aden—In hot climates rocks considered to cause fevers—Central India—South America—Dr. Heyne on ferruginous granite rocks—Granite of Hong Kong—Limestone of Scinde—Fevers in such places not from marsh poison.

In the preceding chapters we have seen that, though marshes and malarious forests frequently abound with decomposing vegetable matters, the feature which chiefly distinguishes them from other and healthier places, is humidity.

That the damp of a marsh is more closely connected with the origin of malaria, than the vegetation with which it is associated, is shown conclusively by the prevalence of malarious fevers in moist, ill-drained places, where vegetation and even stagnant water, in the usual acceptation of the terms, are absent.

In certain tracts of barren, sandy country, very little raised above the level of the sea, on the coasts of Holland, the British army has, more than once, suffered terribly from malarious fever.

Sir J. Pringle, writing of the campaign of 1747, says: "These men, partly in camp and partly in cantonments, lay in South Beveland and the island of Walcheren, and were so sickly, that at the height of the epidemic, some corps had but 100 men fit for duty, or less than one seventh of a complete battalion. The Royals in particular, had but four men who had not been ill. The officers also were sickly, and the

fever was more severe, and fully as fatal, to the natives as to the troops."*

At the time the army on shore was suffering so severely, "Commodore Mitchell's squadron, which lay at anchor in the channel between South Beveland and Walcheren, was not attacked by fever or dysentery, but enjoyed perfect health."* The cause of the sickness, therefore, which raged amongst the troops on land, encamped on either side of this narrow channel, was evidently local; yet there was no decaying vegetation nor putrid water.

In later campaigns in the same country, our army suffered as severely, or even more so.

Fergusson says, that in August 1794, after a very hot and dry summer, intermittent and remittent fevers were epidemic in the army encamped at Rosendaal and Oosterhout in Holland; adding: "The soil, in both places, was a level plain of sand with perfectly dry surface, where no vegetation existed, or could exist, but stunted heath plants." He continues however: "On digging, it was universally found to be percolated with water, to within a few inches of the surface, which so far from being at all putrid, was perfectly potable in all the wells in camp."† In 1810, observes the same writer, on similar soil at Walcheren, the army suffered in a degree nearly unprecedented in the annals of warfare.†

The history of this last-named expedition is scarcely yet forgotten.

After the campaign in Brabant, in 1748, our army suffered very severely from malarious fevers, in cantonments near Eyndhoven and Bois le Duc. Pringle says: "This part of Brabant is nearly as flat as any part of the Netherlands; the only inequalities being some sand-hills and insensible risings, which give the advantage of a few feet in height, to some of the villages. The soil is a barren sand, and so little water is to be seen, that at first sight the country might seem to be dry and healthful. But the appearance is deceitful; for

* *On Diseases of the Army*, i. vii. 57.

† *On the Nature and History of the Marsh Poison.* Trans. Royal Society Edin., 1823, Vol. ix.

water is everywhere to be found at the depth of two or three feet; and in proportion to its distance from the surface, the inhabitants are free from diseases."*

The country near Bois le Duc had been inundated; but the sickness was very great at Eyndhoven, "which lay at some leagues distance from the inundations, and from other marshy grounds."† Pringle goes on to say: "The moisture therefore in most of the cantonments, arose principally from the subterraneous water, which exhaled through the sand. There were two villages near Eyndhoven, called Lind and Zelst, the one ten, and the other fourteen feet above the surface of the water, an extraordinary height in that country, and it was observable that the soldiers kept their health much better in both these places, than in any other of the cantonments."†

Here, then, we have a further clue to the nature of the marsh poison. The malaria was as intense as amid the rankest vegetation; while dampness was the only feature that the barren sandy plain had in common with marshes. The men cantoned in the drier villages suffered least in Brabant; and those in dry and warm quarters, on board ship, escaped entirely at Walcheren, in both expeditions.

To quote another example:—"Wilmington, North Carolina, is situated on a series of dunes. The soil is entirely sea-sand, so dry as to be unfit for horticultural purposes; and only such vegetation as thrives in the lightest soils, a few vines and garden vegetables, are raised by the aid of enriching manures. The natural growth is scrub-oak, pine, and wire-grass. The sand is always dry on the surface, the heaviest rains only moistening it a few inches, the warmth of the sun in a few hours evaporating the moisture, and rendering it dry as before. But this dryness is only on the surface; a short distance below, varying with the elevation or depression of the spot, at which examination is made, water is found in abundance. This water is pure, and fit for drinking."

"Wilmington, in common with several other places, similarly situated on the same coast, was very subject to all the varie-

* *On Diseases of the Army*, i. S. 62-63. † *Ibid.* i. S. 63.

ties of malarial and typhoid fevers, until an extensive system of artificial drainage was adopted, when there was a marked improvement in the health of the city; but during the war the works were neglected, and it again became unhealthy."* Here is a place noted for the prevalence of malaria; but there is no rank growth, scarcely any vegetation at all; damp, in fact, is the only feature of the marsh present.

The malarious shores of the Persian Gulf have many points in common with the situations just referred to.

Fergusson mentions, that in the Peninsula, during a very hot June, when several regiments bivouacked in some hilly ravines, which had lately been watercourses, many of the men were at once seized with remittent fever.† These ravines were too steep for vegetation or for soil to lodge, but a few pools of water remained amongst the rocks.

So far, in each instance quoted the humidity has been evident; water having been in each case close to the surface. In hot climates, however, malarious fevers may prevail where visible moisture is wanting; where, as Fergusson says, "the marsh has ceased to be a marsh;" or even where it has never existed; and wholly irrespective of vegetation, living or dead.

"Whatever may be the cause," says Hennen, "it is certain that in many countries, the malaria does not arise, until all the surface water has totally disappeared, and left the whole face of the country, including the very courses of the winter streams, an arid desert."‡ In India this is constantly the case, and so it is in most hot climates.

"It (malaria)," says Morehead, "often co-exists with decaying vegetation, but not unfrequently seems independent of it; in situations where the soil is sandy, dry, and bare, and where the drying, that essential condition in the generation of malaria, must be going on in the damp subsoil."§

Fergusson relates a number of cases in point. Thus in the

* *New York Medical Journal.* Vol. ix. Aug. 1869.

† *On the Nature and History of the Marsh Poison.* Trans. Royal Society of Edin. Vol. ix.

‡ *Medical Topography*, p. 19.

§ *On Disease in India.* i. 6.

valley of the Guadiana, the army was almost destroyed by remittent fever, the country being so dry from want of rain that the river was only a chain of pools.

Upon the Agueda near Ciudad Rodrigo, in a bare, open, hollow country, which after being flooded had become dry as a brick ground, the army suffered from fevers, which, for malignity of type, could only be equalled by those on the Guadiana.

"At the town of Corea, in Estremadura, not very dissimilarly situated on the banks of the Alagon (also a very pure and limpid stream), our troops experienced similar results; with this addition clearly demonstrated, that no spot of the pestiferous savannah below the town was so much to be dreaded, as the shores of the river."*

"There was not," adds this writer, "an aquatic weed, nor a speck, nor line of marsh to be seen within miles of the town, nor anything but dry, bare, and clean savannah."*

The deductions drawn by Fergusson, from these and similar instances, were, that marshes could be only injurious when they had become dry, and "when the sensible putrefaction of water and vegetable had become alike impossible;" and "that a healthy condition of soil, in these pestiferous regions, was infallibly regained, by the restoration of the marshy surface, to its utmost vigour of vegetable growth and decay."*

Though in this, Fergusson went too far, it is clear that he was right in supposing the presence of vegetation to be unnecessary to the production of malaria.

A case, very similar to one of those already mentioned, occurred in Abyssinia. A detachment of four European officers and eighty sepoys, with some thirty or forty servants and artificers, was sent to make a road through the Hadoda pass, which in the rainy season becomes the bed of a torrent. The surface was then perfectly dry, and consisted of sand, boulders, and rock; but water was found on digging some feet below.

The detachment encamped on loose sand, about fourteen

* *On the Nature and History of the Marsh Poison.* Trans. Royal Society Edin. 1823. Vol. ix.

feet above the bed of the torrent, at a distance from trees or vegetation of any kind.

The heat by day, reflected from masses of bare rock, was intense, and at night there was a great fall of temperature, with very heavy dew.

In a short time quotidian fever broke out, and at the end of a month, every man in camp was laid up with it, except one sepoy. The disease was in some cases complicated with dysentery. A detachment of Indian Cavalry, which had previously encamped in the same place, suffered very severely, both in men and in horses.

Humboldt noticed the co-existence of malaria with barrenness and intense drought, and wondered at it, as a believer in "marsh poison" well might. He says of the hot and arid Llanos of Venezuela: "If the hot valleys of Aroa, Yaracuy, and Rio Tocuyo, celebrated for their excellent timber, be rendered feverish by luxuriance of vegetation and extreme humidity, it is different in the savannahs of Moonai and Carora." And he adds:—"It is extraordinary to see barren savannahs loaded with miasmata."*

Again, the same writer mentions, "the barren yet feverish savannahs extending from Barquisemeto to the eastern shore of the lake of Maracaybo."*

In the Wed R'hir of the great Sahara, there is no stream, and only two or three springs exist in a distance of more than 100 miles; but some twenty or thirty feet below the surface, and in some places much more, is a water-bearing stratum from which water is raised by rude artesian wells. In this district, and in all the oases of the desert, fever is rife in the hot season and in Autumn.†

Here, where all weeds from the sides of the irrigation channels, are carefully collected for fodder, and horses are fed upon pounded date stones, malaria can scarcely arise from decomposing vegetation.

The large military station of Mean Meer, in the Punjab, is

* *Narrative of Travel.* xvi. 66, 67.

† Tristram, *Travels in the Sahara*, 287.

situated on an elevated, arid, and perfectly barren plain, free from any trace of marsh or stagnant water. The surface soil is sand, and the subsoil clay, with calcareous tufa. Scarcely any vegetation exists, and little organic matter is in the soil; yet malaria is never absent and the hospitals, in some years, are crowded with intermittent and remittent fevers. I have already referred to the 106th regiment which in 1867 at this station had 1133 cases of fever in 768 men. In some seasons, on the other hand, no more cases of fever occur at Mean Meer, than at some of the healthiest stations in the plains; and this of course without any change in the soil, or vegetation.

"At Mean Meer, last September," says Dr. De Renzy, in his Report on the Sanitary Administration of the Punjab, for 1868, "there was a great deal of intermittent fever, although from the failure of the rains, the soil had been perfectly dry for months."*

The diurnal range of temperature at Mean Meer is often very great.

In the desert districts, to the southward of the Punjab, malarious fevers are very prevalent; the heat, too, is intense and the variations of temperature are extreme.

Dr. Moore remarks: "The inhabitants of villages scattered here and there throughout the desert tracts of Marwar, Jeysulmere, and Bickaneer, suffer frightfully from fever, and especially so during the cold season."†

At this time, it is to be observed, the nightly cold in these regions is very severe.

Dr. Moore further remarks of the sandy deserts of Western Rajpootana: "There are not floods or heavy rains, to deposit organic matter on the surface, there is little or no organic matter mixed with the sand. Water is some 200 feet from the surface, and the under stratum is a layer of sandstone. Yet as before remarked, the dwellers in these regions, are martyrs to so called malarious disease."‡

The military station of Jacobabad, in Scinde, is 220 feet

* *Medical Times and Gazette.* April 23rd, 1870.
† *Indian Ann. Med.* 1865, vol. x. 380. ‡ Op. Cit. 380.

above the level of the sea. The surrounding country is desert, flat, sandy, and dry.

"There is no wood, jungle, or water in the vicinity". Water is found at a depth of 37 feet from the surface, and is brackish. For drinking purposes, this fluid is brought from the Indus, a distance of 52 miles, by small canals, and is stored in tanks, "but these have no prejudicial effect on health." The highest rainfall in any year since 1851, has been 8 inches, and the lowest 2½ inches.*

Here, are few of the supposed sources of "marsh poison;" yet malarious fever is very prevalent; the number of cases occurring annually amongst the troops (all natives), from 1852 to 1860, varying from 688 to 2136 in 1000 men.

"The usual fever of the country, from which few escape, is intermittent; quotidian and tertian."*

In connection with the remarks just made, it is important to observe that, "the heat is excessive, and the variations of temperature are very great."*

Even barren rocks may abound with malaria. Thus Gibraltar is not free from it, though there is little vegetation or soil to furnish miasmatic exhalations. Hennen mentions intermittent and remittent fevers, and dysentery, as the diseases of most importance amongst its inhabitants.†

"In the Ionian islands," says Davy, "remittent and intermittent fevers break out in places remarkable for aridity and want of water, and almost destitute of vegetation; as part of Zante, Meganissi, and Vido,—these two latter are almost barren rocks."‡

In some of the low ranges of hills in Southern India, malarious fevers, of the most deadly type, prevail in the hottest and driest season.

These diseases are to be found alike, amongst hills covered with wood, and amongst others destitute of trees; while even on the forest-clad hills, at this season, the trees are in most cases bare, and all vegetation is parched and burnt up.

* *Report of Royal Commission on Sanitary State of Army in India.* ii. 860-861.
† *Topography of the Mediterranean.* p. 45.
‡ *Topography of Ionian Islands and Malta.* 247.

Mc Kinnon observes: "The prevalence of fever in some dry localities, in hill-forts and on table-lands in India, is well known."*

In the hilly districts of China, fevers occur, similar to those prevalent in Southern India, though there is no jungle. "The hill-sides at Hong Kong and Amoy," says Dr. Eatwell, "are bare of trees, yet the malarious fevers which I witnessed at those stations, during some three years of residence in them, exceeded in malignity anything I have ever seen in Bengal."† Here, there being no forest and little or no swamp, the crumbling granite rocks are supposed to exhale the "paludal poison."

Kirke, in his "Topography of Seinde," mentions that fevers prevail in the bare, dry, Booghtee hills, where rain seldom falls, and water never stagnates.

The sun-baked rock of Aden, where vegetation does not exist, and where water is a luxury, is the last place where anyone would expect to meet with "the marsh poison;" yet fevers of remittent, and of continued type, (known as Aden fever,) are common, as also is 'intermittent.' The latter prevails more especially amongst the native population. In 1859, there occurred amongst the white troops, 356 strong, 82 cases of intermittent and remittent, and 242 cases of continued fever. Amongst the black troops, 1175 strong, at the same time, there occurred 109 cases of 'intermittent' only.‡

The surgeon of H. M. S. Highflyer mentions that eight cases of remittent fever, on board that ship, were consequent upon exposure at Aden.§

In most hot countries, arid and stony places are considered by the natives to be feverish; and in general, the more dry and barren, (and therefore the hotter,) the locality, the worse is its reputation. The people of Jhansi, and of other towns in Central India, attribute the fevers which so often prevail

* *On Climatic Fevers.* Bengal Ann. Med. no. v. 1855.
† *Report Royal Commission on Army in India.* i. 480.
‡ *Ibid.* ii. 845, 852.
§ *Naval Medical Report.* 1866.

there, to the influence of the bare rocks, by which they are surrounded. Humboldt found a similar idea prevailing in South America, amongst both the Indians and the Spaniards.†

Dr. Heyne attributed the hill fevers of Southern India to the magnetic influence of ferruginous rocks. The malaria of Hong Kong, as already observed, has been ascribed to the friable granite, of which the island is in great part composed. Kirke, too, considered the fevers of Scinde to be caused by exhalations from magnesian limestone. I shall have to allude to this subject again; but in the meantime it must be allowed that malarious fevers, in these situations at all events, cannot arise from "marsh poison," or from any exhalations, produced by decomposing vegetable matter.

In the preceding chapters it has been shown:—

1. That, though malaria prevails very generally in swampy districts, some marshes are almost entirely free from it; the vegetation in each case being equally rank, and its decay equally certain and rapid:—

2. That malaria abounds in damp and ill-drained places, where vegetation is scanty, or entirely absent:—

3. That, in many instances, both in hot and in cold climates, people are brought into contact with, and live surrounded by, masses of decomposing vegetable matter, giving off fœtid exhalations, without becoming subject to malarious disease:—

4. That experiments made with decaying vegetable matters, have produced no symptoms at all resembling those of malarious fever:—

5. That, under the equator, the most healthy season is that in which the muddy banks of rivers and lagoons, loaded with organic matters, are exposed to the greatest extent to the influence of an almost vertical sun; and the most unhealthy season is that in which all the rivers are full, and the swamps well covered with water:—

6. That in hot climates, moreover, malaria may, and does, prevail in its utmost intensity on barren rocks and in sandy

† *Narrative of Travel.* xx. 242. xxv. 515.

deserts, where vegetation does not exist; and where no trace even of moisture is visible: and that here, too, the same diseases are produced, as in the swamp or forest.

All these circumstances being considered, how is it possible that malaria can be a marsh poison? or can be caused by exhalations from decaying vegetation?

CHAPTER VI.

SOME SUPPOSED SOURCES OF MALARIA.

Idea of marsh water causing malarious disease very ancient—Malaria not confined to the neighbourhood of marshes, nor to drinkers of marsh water—In India, soldiers, officers, and civilians often drink from same source, yet soldiers suffer most from malarious disease—In many places water containing vegetable matters, and not filtered, is drunk without producing malarious fevers—Dr. Eatwell's observations in China—Dr. Falconer, on travellers in the Terai—Sir J. Pringle, on the water in Holland—Dr. Parkes, on the water of Sierra Leone—In northern India, water supply chiefly from wells, often in barren places, yet no exemption from malaria—Epidemics arise and subside, the people still drinking water of the same quality and from the same source—Recently excavated soil said to produce malaria—Hong Kong—Analysis of soil—Malaria existed previous to excavations—Excavations in healthy districts do not cause malaria—Damp or marshy ground malarious with or without excavation—Superficial soil contains more organic matter than subsoil—Cultivation, which involves disturbance of the soil, supposed to destroy malaria—Diminution of malaria really due to drying of soil, and consequent climatic changes—Sir J. R. Martin's remarks—Malaria very prevalent in some highly cultivated districts—Mere fact of being cultivated or uncultivated does not render a district malarious or otherwise—But drying of a damp soil does generally diminish disease.

The idea that fevers and diseases of the spleen are caused by drinking marsh water is very ancient, and its origin is easily traced to the fact, that the habitual drinkers of marish water, as they must live in marshy districts, are pretty sure to be liable to malarious disease. But they would be so, if they procured their drinking water from other sources.

If malaria was confined to swampy localities, there might appear some reason to connect the marsh water and malarious fevers as cause and effect; but these diseases are not confined to such situations, as we have seen that they constantly prevail in the most arid and barren places, where there is no vegetation to contaminate the water. It is found moreover, that whether people drink from ponds, lakes, rivers, or wells, it makes no difference in their liability to malarious disease.

There are many places in England, and still more in Ireland, where the drinking water is taken from ponds and ditches, and contains large quantities of vegetable matter, yet where ague is unknown.

In India, the troops, their officers, and the civilians resident in the neighbourhood, frequently drink from the same source, whether river, tank, or well, and in the great majority of cases, with an equal want of care in filtering the water; yet the soldiers suffer from malarious fevers, as we shall presently see, very much more severely than either of the other classes. If the water is in fault, whence does this difference arise? If soldiers drink much more water than other people, they have been sadly belied.

"At Amoy and Hong Kong," says Dr. Eatwell, "I formed a strong opinion against the water having anything to do with the production of the fever, not only from the condition of the water itself, but from the fact, that I had observed that persons on board ship at Amoy, had enjoyed at a distance of a few miles from the land, perfect immunity from the fever, which struck down the whole garrison on shore; although the water used, was the same in both positions."*

Dr. H. Falconer observes: "People are seized with Terai fever after passing through the Terai in the most expeditious manner, without tasting food or drink, that they have not carried with them."†

Sir J. Pringle remarks: "The water drunk by the army in Holland was plentiful and good, the only exception being in Zealand; but in all other places it was blameless; and particularly in the two seasons in which the bloody flux was most frequent."‡

Dr. Parkes says that the water at Sierra Leone is very pure.§ Over by far the greater part of Northern India, the entire water supply is taken from wells, often of considerable depth, yet malaria prevails everywhere. Some of these wells are in barren places, where any contamination from vegetable

* *Report of Royal Commission on Sanitary State of the Army in India*, i. 481.
† *Ibid.* i. 308. ‡ *On Diseases of the Army*, ii. 2. 91. § *Hygiene*, p. 578.

matter is in the highest degree improbable; yet the people who use them are no more exempt from fever, than those who drink from tanks and ponds. Moreover, everywhere occasional outbreaks of malarious disease appear, and again subside; the people still drinking from the same source.

It seems pretty certain, therefore, that the imbibing of marsh water, or of an infusion of vegetable matter, is no more necessary to the production of malarious disease, than is the inhaling of marsh air.

Recently-excavated ground has been said to produce malaria, and this has been alleged as a proof that the poison results from organic matters in the soil.

At Hong Kong, and more especially at Kowloon, in China, excavation of the earth was said to be one of the chief causes of the sickness amongst the troops. Yet the soil is described as for the most part barren, consisting chiefly of disintegrated granite, and a specimen of it, on analysis in the laboratory of the army medical school, was found to contain less than two per cent of organic matter.* Whence then, we may ask, arose the poisonous exhalations, supposed to have caused the sickness, which occurred amongst the troops?

The report of the principal medical officer in China for 1863, a year before the occurrence of the outbreak of malarious disease for which the excavations were blamed, states: "Very little doubt can be entertained, as regards the unhealthiness of Kowloon as a military station. This arises from the imperfect state of drainage; the proximity of the huts to the rice fields; and in a great measure to the huts themselves; suffice it to say, that few men are stationed there for lengthened periods, that do not suffer from fever of the intermittent type."†

Mr. Snell, in his evidence before the Parliamentary Committee, says: "A residence at Kowloon, of men of the 99th Regiment, for any period over a month or six weeks, (I

* Parkes. *Hygiene*, p. 295.

† *Parliamentary Report, China*, 1866. p. 296.

mean before any cuttings or excavations were commenced there) was pretty sure to be followed by attacks of remittent or intermittent fever."*

It is very clear, therefore, that there was no occasion to blame the excavations, for the sickness at Kowloon. At Hong Kong, all those men escaped fever who were not exposed to the influenee of a tropical sun by day, and to the damp and chill at night;† though they must have been equally exposed with their comrades, to any exhalations from the soil or rock.

I have been unable to discover any instance, of malaria having been developed in a previously healthy locality, by simple disturbanee of the soil. The vast earthworks in eonneetion with the railway system, throughout England, never introduced malaria into districts, in which it was not well known before; and in India, I have known many instances of very large excavations carried on at all seasons of the year; but in none was malaria produced.

On the formation in 1867 of the new eantonment of Bukloh, in the lower range of the Punjab Himalayah, hills were cut down, hollows filled up, roads made, and foundations dug for houses and barracks. This work was carried on throughout the year, most of it being done by the sepoys, who with their officers were encamped elose to the newly opened earth; yet fever was almost unknown amongst either Natives or Europeans.

At, and near, Dalhousie, during five successive years, very extensive excavations, amongst vegetable mould, clay, and crumbling granite, produced no malaria. At Bulloon, in the same neighbourhood, where several hills were cut down, and a large extent of ground levelled for a new cantonment, the health of the white troops, who were for a great part of the year employed upon the works, was excellent. So also was the health of the soldiers employed upon the Abbotabad and Murree road, and on other works of a similar nature.

In the seven years, from 1863 to 1869, 4640 white sol-

* *Parliamentary Report, China*, 1866. p. 6.
† *Op. Cit.* p. 2.

diers were employed on public works in the hills in India. During this time, there were but three deaths from fever, and one from dysentery.* Yet nearly all the men were engaged in excavation.

Major-General Cotton, R.E., an officer of very great experience in the matter, in answer to a question, as to whether he had noticed any development of malaria in the south of India, on turning up new ground, says: "In healthy situations, newly cultivated land has not led to sickness in southern India."†

The result of the author's observations in the Baree Doab of the Punjab, at a time when much jungle land was taken into cultivation, is to the same effect.

That damp and marshy ground, cultivated or occupied for the first time, should be malarious, is not to be wondered at; but the disturbance of the earth should not be blamed for this.

The superficial soil in cultivated districts, receiving, as it does, all animal and vegetable debris, as well as manures, contains more organic matter than the deep subsoil; consequently, the widespread disturbance of the former, by the plough, must expose a much greater proportion of such matter, than the comparatively limited excavation of the latter. But cultivated land is considered healthy. We must therefore look to some other cause than the laying bare of organic matter, for the prevalence of malarious disease, which sometimes attends the opening up of new ground.

This is to be found in the exposure to climatic influences, to which those are subject, who occupy new and often damp positions, before proper shelter or drainage has been provided.

When, (as frequently happens,) on the provision of sufficient protection from the weather, malarious disease diminishes, some mysterious change is supposed to have taken place in the air or soil.

Thus, when troops were first sent to Arracan, the mortal-

* *Abstract of Report of Sanitary Commissioner to Government of India.* 1870.

† *Report of Royal Commission on Sanitary state of Army in India.* i. 127.

ity amongst them, whether European or Indian, was very great. Some years afterwards, Dr. J. McPherson, with regard to the samo country, observes: "The experience of recent years has shewn that there is nothing very inimieal to the health of European offieers in the elimate of Khyouk Phyoo, and the mortality in former years was mainly owing to the want of good houses, to unnecessary exposure to the sun, and to the irregular habits of life whieh used to prevail, at Akyab more especially."*

It is tolerably certain that an improved state of health is, in many other plaees, owing to better protection from elimatic influenees, rather than to any change in the nature of the soil.

Malaria prevails so frequently in wild districts, and so often disappears from those which have been cleared, drained, and eultivated, that tillage is often spoken of, as the only thing necessary to render a malarious district healthy. Thus Dr. Piekford says: "Nothing conduces to eheck the generation and propagation of malaria, so much as a high state of eultivation, and a dense population."†

It is however to the drying of the soil, and eonsequent elimatic changes, that this diminution of malaria is really due,

Sir J. R. Martin justly observes that, "when marshes are drained; the rivers flow in their disencumbered channels; the axe and fire clear away the forests; the earth furrowed by the plough, is opened to the rays of the sun, and the influence of the wind; the air, the soil, and the waters, acquire by degrees a character of salubrity."‡ But all this amounts to no more, than that by these means the soil becomes drier.

Merely driving a plough through the land, does not banish malaria, nor does any specific action of the crops upon the ground. For example, the highly cultivated plains of Lombardy are noted for their insalubrity. In the Southern states of North America, in the West Indies, and in China, malarious fevers co-exist with a very high state of cultivation. And these diseases are never absent from the populous and fertile

* *Notes on the Military Stations and Health of the Troops in Arracan.* p. 17.
† *Hygiene.* p. 243. ‡ *Influence of Tropical Climates, &c*, p. 21.

plains of upper India, which have for ages been covered, every year, with splendid crops of wheat, and are so carefully cultivated, that scarcely any pasturage is left for cattle.

The mere fact then, of being cultivated or uncultivated, does not make a district malarious or otherwise; though whatever tends to the drying of a damp soil has, in most climates, a decided influence in rendering it more healthy.

CHAPTER VII.

VARIOUS THEORIES FURTHER CONSIDERED.

The origin of malaria has been sought in certain geological formations—In hot climates, no formation free from malarious disease, and in cold climates, it is not confined to any partieular rock or soil—Stiff retentive soils or impervious subsoils sometimes favour development of malaria, but it exists where they do not—Dr. Falconer's opinion—No proof of any connection between electricity and malaria—Gases evolved in marshy places do not cause ague—Dr. Aitken's remark—Sulphuretted Hydrogen not malaria—Some have supposed malarious disease to be caused by living organisms—Dr. Salisbury's reported discovery—Objections to his theory—Dr. Salisbury's later observations—Further remarks on his theory—Whatever the origin of infectious diseases, malarious fevers, which are not infectious, cannot arise from the same or a similar cause—Dr. Salisbury's views not confirmed.

The geological formation of malarious countries has naturally attracted the attention of many observers; some of whom have considered, that the origin of malaria may be traced to particular rocks or soils. But on comparing the results of investigations made in different regions, it is evident that there is scarcely any description of rock or earth in conuection with which, malaria does not exist; while formations for which, in some districts, it appears to show a preference, in others, are almost entirely without it.

To enumerate particular soils with which malaria is associated would be useless, for in hot climates, no formation, old or recent, has invariably been found free from it, and in cold climates, it is not confined to any especial constituent of the earth's crust.

In such an extent of country as British India, the geological conditions, must necessarily present very great varieties; yet it would be impossible to find there any single district, which is wholly exempt from malarious disease. If in some situations one description of soil appears to favor the development of malaria, in others, a formation of a totally different character, seems to do the same.

Heyne accused ferruginous granite, and Kirke, magnesian

limestone, others have attributed fever to laterite, or clay; but it is confined to none of these. There can be no doubt that stiff retentive soils, or even lighter descriptions with impervious substrata tend, under certain conditions, to favor the development of "malaria;" but it is found where these do not exist.

Dr. Hugh Falconer, a very eminent authority on this subject, says: "It strikes me, that it is not so much a question of geology, as one of the physical configuration of the country; and that the mere nature of the rocks, or the abstract geological conditions, have but little to do with it."*

As to the connection between malaria and electricity, there is some scope for investigation; but in the present state of our knowledge of its influence upon the animal economy, there is nothing to show that this force is in any way, directly or indirectly, a cause of malarious fevers. The effects of electrical action upon man and other animals, have been demonstrated in numberless instances, but malarious disease has in no case been produced.

Some writers have observed, that a prevalence of epidemic disorders has been associated with certain variations in the electric state of the atmosphere; but while it is quite possible that some such conditions may be more favourable than others to the spread of disease, the narrow limits within which malaria is often confined, and the isolated cases of periodic fever which so often occur, render it in the highest degree improbable, that any general electric disturbance can be the cause. "Malaria" too, as I have shown, prevails under the most varied and opposite conditions of the atmosphere, from the extreme of moisture, to the extreme of dryness; and under very dissimilar terrestrial conditions. It is common in countries where electrical disturbances are frequent and violent; and in others where, as in Peru, thunder and lightning are unknown.†

As might be expected, many examinations have been made of the gases evolved in marshy spots, in the expectation that

* *Report of Royal Commission on Sanitary state of Army in India*, i. 305.

† *Kosmos*, i. 335.

the cause of malaria would be found in them. After much patient investigation, it is generally admitted that these gases consist chiefly of carbonic acid, with carburetted, phosphuretted, and sulphuretted hydrogen. None of these, either individually or in combination, will produce anything resembling malarious disease; even when inhaled in a much more concentrated form than that in which they exist in the atmosphere of the most deadly marsh. In fact, as Dr. Aitken observes, "No poisonous principle has yet been chemically demonstrated in the air of malarious regions."*

Travellers have often perceived strong evidence of the presence of sulphuretted hydrogen in unhealthy localities, and Professor Daniell and others have attempted to connect this with the development of intermittent and remittent fevers, but those diseases are just as intense in other places, where no trace of the gas can be perceived.

In some parts of the Punjab, and elsewhere in India, if the water taken from any well be allowed to stand even for a day, it emits a very offensive odour of sulphuretted hydrogen, yet neither the inhalation of the effluvium, nor drinking the water, is found to produce malarious fever.

Livingstone observes, of the Zambesi: "The flood water ran into a marsh some miles above the mountain, and became as black as ink; and when it returned again to the river emitted so strong an effluvium of sulphuretted hydrogen, that one could not forget for an instant that the air was most offensive. The natives said this stench did not produce disease. We spent one night in it, and suffered no ill effects, though we fully expected an attack of fever. Next morning every particle of white paint, on both ships, was so deeply blackened, that it could not be cleaned by scrubbing with soap and water. The brass was all turned to a bronze colour, and even the iron and ropes had taken a new tint. This is an additional proof that malaria and offensive effluvia are not always companions."†

In many countries sulphureous springs are resorted to for

* *Science and Practice of Medicine*, 5th edit., i. 504.

† *Expedition to the Zambesi*, xxviii, 575.

the cure of various disorders, but malarious disease is certainly not a common result of the use of the waters, or of a residence in their neighbourhood.

Several observers have, at different times, endeavoured to connect the origin of malaria with the presence of germs of organic matter.

In 1866, Dr. Salisbury, of Cleveland, Ohio, announced his discovery of the cause of malarious fevers, in the spores of Gemiasma, a form of algoid vegetation resembling the Palmellæ. This writer reported that he had found these vegetations abundant in marshes, and on the surface of newly excavated earth, in marshy places, where the residents were subject to intermittent fever; he also found them in the sputa and urine of patients suffering from that disease. The spores of other forms of vegetation were also frequently found in the urine of ague patients, but these the doctor considered to be "the consequence, and not the cause, of the pathologic state." This writer further stated, that on visiting the spots at which these growths were most abundant, he experienced "a dry, feverish, constricted feeling, in the mouth, fauces, and throat. This feeling increased, till the fauces and throat became unpleasantly parched and feverish." The same sensation "extended to the bronchial and pulmonary surfaces." There was "a constant desire to swallow, hawk, and spit." These symptoms lasted for about two hours after leaving the marsh, and were considered by Dr. Salisbury, to be caused by the inhalation of the "malarial matters;" they were felt on many different occasions by the doctor, as well as by several friends who accompanied him.

Dr. Salisbury found, too, that "cryptogamic spores are mainly elevated above the surface of the ground, during the night;" that "they rise, and are suspended, in the cold damp exhalations from the soil, after the sun has set, and that they fall again to the earth, soon after the sun rises;" —that they rise from 35 to 100 feet from the surface;—that "above the summit plane of cool night exhalations, these bodies do not rise, and intermittents do not extend:"—also that "the day air of malarial districts, is quite free from

these palmelloid spores, and from causes that produce intermittents.*"

Dr. Salisbury next removed some boxes of earth, containing palmelloid plants, to a distance of five miles from the malarious district, and placed them on the window-sill of a room, in which two young men slept; the window being left open. Within fourteen days, both young men were attacked by intermittent fever.† It is not said, however, that these men had not visited the neighbouring malarious localities; nor is it clear, that the damp, chill, night air, entering through the open window, may not have caused the ague.

There are several objections to this theory of Dr. Salisbury's; the most obvious being:—

That exhalations from the soil are most active by day. At night condensation takes place, and the tendency of the chilled air, with the moisture and all matters suspended in it, is to descend towards the surface of the earth.

Again, though Dr. Salisbury and his friends repeatedly experienced the sensation of irritation of the throat and bronchi, caused by inhalation of the spores, which were even detected in the sputa, they were not attacked with intermittent fever.

Further, although the peculiar symptoms, produced by the inhalation of the spores, were experienced by so many people during the day, Dr. Salisbury says the day air of malarious places is free "from causes that produce intermittents."

Still further, as a moist atmosphere is essential to the existence of these vegetations, it is impossible that they can live in hot, dry, and parched countries, amid barren rocks and sandy deserts where malaria, nevertheless, is very prevalent.

A later work of Dr. Salisbury's† throws no further light upon this subject. In it, he ascribes the origin of other forms of fever to the invasion of the body by vegetable or-

* *American Journal of Medical Science*, Jan. 1866.

† *Microscopic Examinations of the Blood and Vegetations found in Variola, Vaccinia, and Typhoid Fever.* New York, 1868.

ganisms, and observes: "The tendency to periodicity in all febrile diseases, probably marks the periods of the successive crops of vegetation." But the doctor does not say what becomes of these successive crops.

We can understand, that if Gemiasma, Biolysis Typhoides, or any similar vegetation, be the cause of a contagious fever, the spores, on becoming ripe, may make their escape from the surfaces of the body; for we know that the surrounding atmosphere becomes contaminated, and that persons exposed to it are liable to be attacked by the same disease; the clothes, too, of the patient become infected. But if malarious fevers be caused by similar organisms, what becomes of the spores produced during a case of ague? They must leave the patient, or he could not recover;—they do not infect the atmosphere, or the clothes of the patient, or the disease would spread through them;—they do not establish themselves upon the bodies of the attendants, or they would be attacked by a similar disease.

If, after reproducing itself to such a marvellous extent within the body, the whole mass of vegetation,—plant and germ,—parent and offspring,—suddenly ceases to exist, what puts an end to its life? and what becomes of the debris?

Again, if, after passing through the human body, these vegetations be incapable of reproducing themselves, they must necessarily exist independently, in the atmosphere of every malarious locality; they must therefore, in hot climates, thrive in marshes and swamps, in parched, sandy deserts, and upon barren rocks; they must flourish and be in their fullest vigor when the air, as well as the earth, is perfectly dry and parched, and all perceptible vegetation is burnt up, and also when both the soil and the atmosphere are saturated with moisture, and drenched and scoured by the tropical rains; the winds blowing down from snow-clad mountains, too, must be loaded with these spores, as they often bring malaria in their train. And yet, in temperate climates, the same vegetations must bo confined to the vicinity of marshes.

To investigate the cause of infectious disorders, or to consider

the applicability of the "germ theory" in their case, is beyond the scope of this work; but it may with safety be assumed, that whatever the origin of those diseases, in which a poison exists, capable of reproducing itself and of being communicated from man to man, it is impossible that malarious fevers, which are not infectious, can arise from the same cause.

If to all this be added, the absence of any confirmation of Dr. Salisbury's discoveries; it must, I think, be admitted, that malaria is not composed of vegetable spores, nor of any living organisms.

CHAPTER VIII.

THE SO-CALLED PALUDAL CACHEXIA, IS IT CAUSED BY A SPECIFIC POISON?

Malaria sometimes said to produce a "paludal cachexia," accompanied, or not, by malarious fever—A generally enfeebled state of health not uncommon in damp marshy localities, especially in hot climates—Effects of combined heat and moisture on white races—Also of repeated attacks of malarious fever—Occasionally aggravated by tendency to scurvy—Cachexia, sometimes met with in natives of hot climates, due to repeated attacks of fever—Often aggravated by want of proper food—Malaria may prevail extensively without causing cachexia, except as a consequence of attacks of fever—Case in point—Action of quinine, in malarious fevers and paludal cachexia, considered a proof of their origin in a specific poison—No foundation for this—Quinine a most beneficial remedy in many affections unconnected with malaria—Not a certain cure for malarious fever—Other remedies for the same disease not considered to have any specific action—Quinine not a certain protection against malaria.

It is sometimes said that "malaria," even without producing fever, causes a peculiar cachexia, characterised by a general derangement of nearly all the organs of the body; and a very large proportion of the disordered health, so common in hot climates, is ascribed to this cause.

That a generally enfeebled state of health should prevail amongst residents in swampy localities, especially in the tropics, is not surprising; apart even from the debilitating effect of repeated attacks of malarious fever, from which it is very certain that few residents in such situations escape. But that any poison beyond heat, moisture, and the effects of repeated fevers, exists in such places, there is no evidence to show. Certainly, nothing more than these is necessary to produce the cachexia.

The effect, upon the white races, of combined heat and moisture is to produce anæmia, to relax and enervate the whole system, to destroy the tone of stomach and bowels, and to cause a constant tendency to diarrhœa, dysentery, and passive visceral engorgements.

When to this is added the debilitating effect of frequent attacks of fever, it is not necessary to look much further for

the cause of "paludal cachexia" of very intense form; even without considering the tendency to scurvy, which sometimes exists in the tropics, from difficulty in obtaining good nutritious food.

It is often found in tropical countries, both in the hills and in the plains, that during the rainy season, diarrhœa is apt to be incontrollable and wounds to become unhealthy; no reason for which can be assigned, but the excess of moisture in the atmosphere. This condition disappears as soon as drier weather sets in, though malaria often then becomes most intense.

The cachexia which is frequently seen in the people of hot climates, is almost invariably the effect of repeated fevers, and is often aggravated by the want of proper food. I have never met with a case of this form of disease in a native of India, who had not suffered from frequent attacks of malarious fever.

The cause of malarious disease may certainly be prevalent, without any one being affected with "paludal cachexia," except those in whom it has been induced by severe attacks of fever.

I have observed this in several places, in which malarious diseases prevailed very extensively for several months of every year. In the Goordaspore district of the Punjab, these disorders are very prevalent in autumn; so much so, that the government workshops at Madhopore are closed during the month of September, owing to the sickness amongst the workpeople; yet, there is no cachexia visible except in those who have suffered severely from fever. Those who escape this disease are evidently unaffected by any specific "paludal poison." The population it may be observed is prosperous and well fed.

The action of quina, in cases of malarious fever and paludal cachexia, is sometimes spoken of as a proof of the origin of those diseases in a specific poison; and we frequently hear it said, that a complaint must have been caused by malaria, as it yielded to quinine. For this assumption however there is no foundation.

This is not the place to enter into the subject of specific remedies; but, although quinine is certainly beneficial in malarious fevers, more so, in fact, than any other drug with which we are acquainted; it is equally beneficial in a number of affections, which are not in any way connected with malaria; it is not a certain cure for either intermittent or remittent fevers; and vast numbers of cases of those diseases are, in all malarious countries, cured without it. Again, the long list of antiperiodic remedies, which are not supposed to have any specific action, testifies to the efficacy of other medicines in these diseases.

Of the hundreds of thousands who every year suffer from malarious diseases, in tropical regions, a small proportion only is treated by quinine, and yet very great numbers recover.

Further, if malaria were a specific poison, and quinine were the specific remedy for that poison, there would be much less room than there is, to doubt the preventive effect of this medicine in malarious disease.

My own experiments in connection with this subject have not been extensive; but, I have known people attacked by fever, who were in the constant habit of taking quinine; and, on the occasion already alluded to, I did not take it while testing in my own person the properties of marsh miasma, yet, I did not suffer from malarious disease. It is probable that, beyond its powerful tonic effect, this alkaloid has no preventive influence unless combined with careful protection from damp and chill.

Livingstone observes: "For a number of months all our men except two, took quinine regularly every morning. The fever sometimes attacked the believers in quinine, while the unbelievers in its prophylactic power escaped. Whether we took it daily, or omitted it altogether for months, made no difference; the fever was impartial, and seized on us, on the days of quinine, as regularly and as severely, as when it remained undisturbed in the medicine chest."*

The same writer however adds: "Although quinine was

* *Expedition to the Zambesi*, iii. 72.

not found to be a preventive, except possibly in the way of acting as a tonic, and rendering the system more able to resist the influence of malaria, it was found invaluable in the cure of the complaint."*

In the frequent naval expeditions, on the coast of Africa, quina is in general use as a prophylactic, yet fevers, often of great severity, constantly occur.

The fact then, of cinchona being the most valuable remedy in malarious fever, does not prove the origin of that disease in a specific poison.

* *Expedition to the Zambesi*, p. 73.

CHAPTER IX.

WHAT IS MALARIA?

The conditions under which malarious disease prevails, very numerous and varied—The same cause must exist in every case—Decaying organic matter, in any appreciable quantity, not always present—Nor when it is so, does it produce malarious fever—No known geological or physical condition of soil or site common to all malarious localities—Nor any poisonous gas—Nor any peculiarity in the electric condition of the atmosphere—Nor any species of organic germ—Thermal and other meteorological conditions afford only opening for further investigation—Sudden variation of temperature to be traced in all histories of epidemic malarious disease—Also, in all descriptions of sites and circumstances favorable to development of malaria—Isolated cases of malarious fever may be thus accounted for—Relapses of this disease caused by chill—Twining's observations—Author's views—Effects of cold—Effects of heat—Circumstances attending development of malaria point to its identity with chill—Observations of Sir J. R. Martin—Difference between damp and dry cold—M. Brachet's experiments—Effects of cold bathing, in hot climates—Night air in hot countries often humid and raw—Dr. Mouat's observations—Remarks of Drs. Arnott and Lind.

As it is clear, that what is called malaria may exist under the most varied and opposite circumstances as to place, season, climate, geological formation, altitude, cultivation, and the general features of a country; it is also evident that the cause, whatever it be, must exist under equally varied conditions. What, then, can be this all-pervading influence, which, invisible and proof against the penetrating researches of chemistry, can produce such effects upon the human race? As we have already seen, the existence, in any appreciable quantity, of decaying organic matter, animal or vegetable, is not common to all malarious localities; nor, when present, does it produce "paludal" fevers.

It has been shown, that no known geological or physical condition, of soil or site, is common to all such places.

The diseases referred to prevail in the absence of any poisonous gas.

The electric state of the atmosphere cannot be the same, under all the various conditions in which malaria shows itself. It is certain, too, that no species of germ, yet discovered, can produce remittent or intermittent fevers.

None of these, then, can be the cause of malarious disease. Having thus determined what malaria is not, let us endeavour to decide what it is.

Thermal and other meteorological conditions afford the only opening left for further investigation. At first sight, these may appear to have little influence in the development of a cause of disease, which is found at all seasons and in almost every climate; but, if we look closely into the matter, one condition may be found whenever and wherever what is called malaria prevails; viz. the rapid abstraction of animal heat.

Sudden change of temperature, from heat to cold, is mentioned in the history of nearly every epidemic of malarious disease; and may be distinctly traced through all descriptions of the sites and circumstances favourable to the development of "marsh poison:" while those isolated cases of the disorders referred to, which writers have found so difficult to account for, are, in most instances, clearly connected with exposure to vicissitudes such as those alluded to. It is, moreover, almost universally allowed, that *relapses of malarious fever are produced by exposure to chill.*

Many writers have observed, that great and sudden change of temperature, especially from heat to cold, is closely connected with the appearance of "paludal disease"; in fact, it seems almost impossible that anyone, who has lived in a malarious country, should not have felt this.

An old Indian officer once observed to me, when we were talking over the sickness in the regiment: "They say it is caused by dead leaves, and vegetation, and malaria; but I know that hot days and cold nights always bring fever."

Twining remarks: "Malaria has been generally acknowledged the efficient cause of intermittent fever; but it is abundantly evident to every medical man in Bengal, the very first year he witnesses the results of the change of season and temperature, between the 20th October, and 1st December, that intermittents are intimately connected with the diurnal changes of temperature, which take place at the commencement of the cold season."*

* *On the more Important Diseases of Bengal*, 556, 557.

Like most people, I began with a firm belief in "malaria;" doubt, however, followed upon a more intimate acquaintance with its supposed effects. At last, some years of careful observation, while serving in different parts of India, in localities differing greatly in physical aspect and in climate, convinced me not only, *that malaria, as a specific poison, does not exist;* but, *that the cause of the diseases attributed to it is chill, or, in other words, the sudden abstraction of animal heat.* I found moreover, that the extreme susceptibility to cold, which is caused by long continued exposure to great heat, intensifies the predisposition to the diseases referred to, thus causing their greater prevalence in hot climates; and that a further effect of great heat upon the system, more especially in the white races, is, by lowering the vital powers, to render the type of disease more grave. Thus it arises, that, in cool climates, the powerfully chilling influence of damp is necessary to the development of malaria. In such climates, consequently, malarious fevers are rarely found in any but humid and marshy spots; and they generally occur in autumn, that being the period of transition from greatest heat to greatest cold and, also, the time when the difference is most marked between daily and nightly temperature.

In hot climates, owing to the predisposing influence just alluded to, a very slight fall of temperature is sufficient to produce chill, and a correspondingly slight cause to give rise to malarious fever; so that the influence of damp may not be necessary. The severity of the disease, thus induced, is generally in proportion to the degree of heat, previously endured, and the duration of exposure to it. That prolonged exposure to great heat is the most powerful predisposing cause of malarious disease is shown, on the one hand, by the certainty with which such disease increases in frequency and malignity with the heat of the climate, the duration of the hot season, and the degree of exposure to calorific influences; and, on the other hand, by the marked diminution both in the prevalence and the intensity of malaria, so far as white men are concerned, in cool seasons, in temperate climates, at great altitudes, or under any condition, which tends to reduce

the average temperature; and even, where the effects of heat are lessened by good and sufficient shelter.

Again, the immediate appearance of malaria with the first fall of temperature, after the greatest heat, at whatever period of the year this may take place; its extraordinary prevalence whenever the change from the hot to the cold season is sudden; its preference for localities in which the variations of temperature are greatest; its intensity at night, when the temperature is lowest; and its energy when assisted by the well-known heat-abstracting power of damp; all show that chill is the great exciting cause of the various diseases attributed to malarious influence. This, too, is confirmed by the facts, that all precautions, which have been found serviceable against the evil influence of malaria, are calculated to maintain the ordinary temperature of the body; and, that the conditions known to favour its attacks upon the system are those, which tend to the sudden abstraction of animal heat.

Sir J. R. Martin observes: "Damp cold must tend to produce in individuals, whose power of developing heat is rather feeble, the series of actions which constitute the accession of intermittent fever; especially if they are exposed to that action during sleep."* If this be the case, what else is necessary to constitute malaria? That it is so, may daily be seen in the, so-called, relapses of malarious fevers.

Damp cold is only more frequently connected with malaria, than cold which is dry, because of its greater power for the rapid and complete abstraction of animal heat; for which, the capacity of the vapour of water is equal to 16,000 times that of dry air.†

Exposure to cold, however, is not only capable of causing relapses of malarious fever, but also of producing the disease in its primary form.

I know a gentleman, who was attacked with intermittent fever, for the first time, in a very healthy part of North Devon, from sleeping on a cold, damp floor in a crowded hotel, while nursing a brother, who was very ill from another

* *Influence of Tropical Climates, &c. p.* 46. Ed. 1856.
† Tyndall, *On Heat*, xi. 372, 373.

complaint. There was no suspicion of malaria in the neighbourhood, and no one else was attacked. This gentleman has, several times since, suffered from recurrences of the same complaint, after exposure to cold or wet.

M. Brachet, of Lyons, tried a series of experiments upon himself, which are alluded to by Sir T. Watson in his lecture on malarious fevers. This gentleman bathed, at midnight, for seven successive nights, in the river Saone. On the first occasion he remained a quarter of an hour in the water; on the second half an hour; till at last he was able to stay in the water an hour. After each bath he went to a warm bed; soon after which he experienced a sensation of heat; profuse sweating followed, during which he fell asleep. "In this way," says M. Brachet, "I took seven baths, and then discontinued them, satisfied with the experiment. But what was my surprise to find on the following nights, between twelve and one o'clock, that my body, having contracted the habit of cold bathing, retained the influence and impression of it; and went through all the phenomena of a true paroxysm of ague. As the evil was slight, since during the day I felt nothing; the appetite being good, and all the functions going on properly, I allowed this artificial fever to continue, and I had six attacks in succession. The seventh night after the discontinuance of the cold baths, I was called to an accouchment at the Croix Rousse, about midnight. The rapidity with which I ascended the hill made me hot, and when I arrived, I kept near a good fire in a very hot room. The attack did not come on, and has never since returned." "If I am not mistaken," adds M. Brachet, "this experiment is sufficient to establish the fact that the point of departure is not always internal; since seven immersions in a cold bath, made at the same hour, have caused, one may say, artificially a true intermittent fever."*

A cold bath is, in hot climates, often followed by much more serious attacks than that of M. Brachet.

Staff Surgeon Gore mentions bathing in the sun as a frequent cause of the fevers of the west coast of Africa;† and, in

* *Observations et Recherches sur les Fièvres Intermittentes*, p. 370.

† *Army Medical Report*, 1867.

other countries, malarious disease has been ascribed to the same cause.

The injurious effect of prolonged cold bathing, in a tropical climate, is the same, whether it be in the sun or in the shade, and is owing to the rapid chilling of bodies whose heat-generating power is low.*

It may possibly be objected, that those who have been attacked by fever after bathing must, necessarily, have been exposed to malaria on the banks of a river or lake or on the sea-beach. But this is not the case, for I have known malarious fever brought on, in India, by a prolonged stay in a cold bath. In one officer, an attack so induced, in a healthy locality and in the dry, hot season, was particularly obstinate and severe.

Malaria is, everywhere, most active by night. It is possible however that some, who would not be much surprised to hear the agues of Lincolnshire attributed to the dampness and chilliness of the night air, may wonder to find malarious fevers attributed to the same cause in a tropical climate. Yet, Dr. Mouat, of the 13th Light Dragoons, quoted by Sir J. R. Martin, mentions, that while serving in the Madras Presidency, out of 3394 cases of disease (of all kinds) treated in the regimental hospital, 1372 soldiers attributed their illness to cold, while only 62 ascribed their disorders to exposure to the sun.†

It is difficult for anyone, who has not visited tropical regions, to form an idea of the bitter, penetrating sensation of cold often experienced, at night, after a day of intense heat.

Dr. Arnott, of the 1st Bombay Fusiliers, quoted by Sir J. R. Martin, says: "The first night the regiment spent in

* M. Armand mentions, that one day while encamped in the valley of Chelif, overcome by the sirocco and the heat, he was tempted to bathe in a neighbouring stream; staying in the water till he began to feel chilly and to shiver. On leaving the water M. Armand found that the sun, which had previously scorched him, did not warm him: an attack of remittent fever immediately followed.

The same writer observes, that, though there was no marsh near, several cases of fever occurred amongst the troops, some of them being of malignaut type. On questioning the men, it was found that they had all been wet the previous day; some from fishing in the Chelif, others from bathing in a stream. *L'Algerie Medicale*, iii. 92.

† *Influence of Tropical Climates, &c.*, p. 89. Ed. 1861.

Scinde, was upon the open bunder (wharf). Most of the men and officers marched about all night, to keep themselves warm, being without tents, bedding, or shelter, they felt the cold severely; and six of the deaths in the regiment during the following twelve months, were traced to that night; and for some years after, it was spoken of, in the regiment, as the cause of its subsequent bad health."*

Lind observes: "The first proof of an unhealthy country, is a sudden, and great alteration in the air at sunset, from intolerable heat, to chilling cold. This is perceived as soon as the sun is set, and for the most part is accompanied with a very heavy dew. It shows an unhealthy, swampy soil, the nature of which is such, that no sooner the sun-beams are withdrawn, than the vapours emitted from it, render the air raw, damp, and chilling, in the most sultry climates; so that even under the equator, in some unhealthy places, the night air is cold, to an European constitution."†

* *Influence of Tropical Climates*, p. 59.

† *On the Preservation of Health in Hot Climates*, i. 1.

CHAPTER X.

INFLUENCE OF THE SEASONS UPON MALARIA.

Prevalence of malarious disease in autumn observed from earliest times—Generally ascribed by modern writers to presence of vegetable decay—Most striking peculiarity of autumnal season great variation of temperature—Malaria not everywhere most prevalent in autumn, but invariably so at the time of transition from hot to cold season—More so in proportion to suddenness of change—Sir J. McGrigor's observations—Fever of last autumn in upper India, and its causes—In hot climates any irregularity of seasons produces malaria—Epidemic of 1809 in south of India—Many highly malarious places free from marsh, but remarkable for extremes of temperature—Kamptee—Jacobabad—Marshy places remarkable for freedom from malaria, also remarkable for equability of climate—Ireland—Singapore—Amazon valley.

From the earliest times, the prevalence of malaria in autumn has been a matter of observation; so much so, in fact, that its existence at other seasons has been almost ignored. Modern writers generally attribute this autumnal prevalence of malaria to vegetable decay; but, even more striking peculiarities of this season, than the fall of the leaf, are the great changes of temperature, and the nightly cold, rendered the more trying from its succeeding rapidly to the continued heat of summer.

Most of the ancient writers ascribe the evil influence of the autumnal season to climatic causes. Celsus dwells particularly upon the effect of previous heat, in preparing the body for the invasion of disease.*

The facts, that malaria is not in all countries most prevalent in autumn, but, that it is so invariably at the period of transition from the hot to the cool season, and always more so in proportion to the suddenness of the change, prove that the prevalence of malaria, at the fall of the year, is due to the climatic vicissitudes which occur at that time; and not

* "Quo fit, ut autumnus plurimus opprimat. Nam fere merediauis temporibus calor; nocturnis atque matutiuis, simulque etiam vespertiuis, frigus est. Corpus ergo, et æstate et subinde meridianis caloribus relaxatum, subito frigore excipitur. sed, ut eo tempore id maxime fit, sic, quandocunque evenit, noxium est." *De Medicina.* Lib. ii. 1.

to the development of any poison from the decaying vegetation which then abounds.

Sir J. McGrigor observes: "In every part of tho world, with change of season, some diseases pretty constantly make their appearance; but in no part is this so observable, as in the countries under the tropics. In the West India islands, as well as on the shores of India, I have repeatedly and uniformly observed, the sick list of a European corps more than doubled, by the third week after the setting in of the monsoon."* This monsoon, it may be observed, sets in during May or June, according to the latitudo.

In Equatorial regions, where the climate is almost uniformly hot, and where, as Humboldt says, it only grows cold after storms of rain, the setting in of the monsoon, or rainy season, ("l'hivernage" as it is termed by Becquerel,)† is the period at which the change from heat to cold is most marked; and it is always the season, as I have already mentioned, at which remittent and intermittent fevers are most prevalent.

At a greater distance from the equator, where a distinct cold season occurs, though it may scarcely deserve the name of winter, the autumnal becomes the malarious season.

At any time, however, in which, after a long period of great heat, a sudden change to cold takes place, malaria appears; and especially, is this the case, if the cold be combined with moisture.

Livingstone observes, that in Central Africa, in lat. 12°. S., fever was very prevalent in July, (corresponding with our January,) when the country was drying after the inundation, that the thermometer, early in the morning, ranged from 42° to 52°, and at noon, from 94° to 96° in the shade, and that whenever the people of a village were enquired for, the reply was: "They are recovering." He adds: "The sensation of cold after the heat of the day was very keen. The Balonda, at this season, never leavo their fires till 9 or 10 in the morning."‡ Here, the evaporation from the damp soil, in an in-

* *Medical Sketches of Army in Egypt*, p. 80.

† *Des Climats, &c.*, p. 124.

‡ *Travels in Southern Africa*, p. 480, 485.

land climate, at an altitude of 4000 feet above the sea, produced a very great degree of cold at night and a consequent universal prevalence of fever, in the dry season; while in the same latitudes, in the low and humid regions of the coast, where such a fall of temperature never takes place, fever, as already mentioned, is most prevalent during the rains.

The influence of a sudden change to cold, from great and continued heat, was well shown in the circumstances attending the outbreak of malarious fever, in Northern India, last autumn. This fever appears to have prevailed most extensively in the Punjab, where also the climatic peculiarities, alluded to, were most marked; it was most severely felt, as autumnal fevers always are, in damp and low-lying districts, but other and healthier localities did not escape. The hot season had been unusually severe and protracted, the natives saying they had never felt such heat; and the rains, at the usual season, were so scanty, that scarcity arose amounting in some districts to famine. At a very unusual period heavy rain fell; and, owing to the lateness of the season at which this occurred, the sun was not sufficiently powerful to thoroughly dry and warm the earth; in consequence of this, there ensued a very damp and chilly autumn and a very severe cold season. In fact, the peculiar characteristics of autumn were exaggerated to an intense degree, and were attended by such a prevalence of malarious fever as had not occurred for many years; which, being general over a very great extent of country, could not well have been owing to any but climatic causes.

So intense was the cold in the Punjab, at the time when people were dying in numbers from this fever, that the thermometer, at night, fell several degrees below freezing point.

In one small town, of 8000 inhabitants, there were 700 deaths from fever and nearly the whole population was attacked. In the moist and highly cultivated, but generally healthy, Kangra valley, the sickness was so great, that, as the natives expressed it, "all those who were well were employed in drawing water for the sick." The tea-planters were unable to procure labour, and the native cultivators could scarcely

till their land. It is officially stated, that this fever "numbered tens of thousands as its victims."*

All the circumstances, attending this epidemic of fever, point to climatic influence as the cause. The poorer classes suffered more, than the richer and better clad. The rural population were attacked more generally, than the people of the large towns; and natives of India more than Europeans. The latter, owing to the superiority of their clothing and houses, their habits of life, and their adaptation to a cool climate, being more capable of resisting the effects of chill and damp, seldom suffer so much, as the people of the country, from cold-weather fevers.

In India, and other tropical climates, it seems that any irregularity in the usual course of the seasons is productive of malaria. If the hot season be protracted, or if the cold season be more severe than usual, malarious fevers are prevalent; but, when both are greatly exaggerated, these diseases become epidemic.

In the years 1809, 1810 and 1811, an outbreak of malarious fever occurred in Coimbatore, Madura, Dindigul, and Tinnevelly, which carried off over 106,000 people. A medical committee was appointed to enquire into the origin of the epidemic; and from the report of this committee it appears, that the years 1804, 1805 and 1807 were very dry and hot, and the years 1808 and 1809 were very wet, with cold winds. To these variations of climate the natives ascribed the sickness. "February, March, and April" the Report states "were the worst months, when the heat by day was very great and the ground still damp. As the season became hotter, the fever was more apt to put on a remittent form, than at an earlier period, when the rains were falling and the atmosphere was comparatively cool." In other words, when the days were very hot and the nights were raw and humid the fever was more severe, than when the climate was cooler and more equable.

On this, as on other similar occasions, there was also great mortality amongst the cattle.

In hot climates, places noted for great and sudden varia-

* *Punjab Jail Report*, 1869.

tions of temperature are often highly malarious, although free from swamp. Thus the large military station of Kamptee, which enjoys the evil reputation of being the hottest place in India; is also one of the most un-healthy. Yet, the site of the station is remarkably free from all supposed sources of malaria, and so is the neighbourhood. The ground is undulating, elevated, and open. There is no marsh. The banks of the small river Kunnan, which runs past the station, are either perfectly bare of trees and vegetation, or are cultivated with the dry grain crops of the country. The bed of the river is rocky and sandy. The jungles, which have been accused of causing the malaria, are at a distance of 15 to 20 miles from the station; and, during a great part of the year, the wind blows from the opposite direction. The soil is the black volcanic earth of that part of the country, consisting chiefly of decomposed trap; it absorbs heat greedily, radiates it rapidly, and is very retentive of moisture.

The climate is remarkable for extremes of temperature. There are heavy dews; and, in the cold season, hoar frost is formed. The thermometer, during this period, ranges from 36° to 110° F. in the shade, out of doors; and in the hot season, *in a good house, shut up,* it varies from 96° to 104° F. The temperature of the barracks is, of course, much higher. In the open air the thermometer rises to 140°. The cold months are the most unhealthy, "and fevers and bowel complaints are not only more numerous, but also more severe, and generally more fatal, during this season of the year;" fevers are however prevalent towards the end of the hot weather, (in May and June,) and throughout the rainy and autumnal periods.*

During 10 years, the average sickness amongst the white troops at Kamptee, (including a small force on the rocky hill of Seetabuldee, near Nagpore,) was, 241·194 per cent; and amongst the native troops, 62·387 per cent; chiefly from fevers, dysentery, and hepatitis.

During the same period, the sickness in the Moulmein command, amid the swampy forests of Burmah, was, amongst

* *Madras Topographical Reports,* 1844.

the white troops, 143·483 per cent; and amongst the sepoys, 67·416 per cent.*

In 1865, the cases of paroxysmal fevers alone, amongst the white soldiers at Kamptee, equalled half their strength.† In 1866, also, the same proportion of white troops, at this station, suffered from these disorders; while in Burmah, though, owing to excessive heat, the sickness was greater than usual, less than 28 per cent of the garrison was attacked by this form of disease.‡ In 1867, there were at Kamptee 846 cases of intermittent and remittent fever, in a strength of 1060 Europeans; the proportion of the same complaints in Burmah being under 20 per cent.§

Therefore, even swampy forests and river banks, like those of Burmah, may be less productive of malarious disease, than a dry, open cantonment, free from marshes and 15 to 20 miles distant from the nearest jungle, where the heat is very great, and the variation of temperature extreme. It will also be observed, that the most sickly season, at this unhealthy station, is that in which the climatic changes are greatest, and chill is most certain to result from exposure to night air. This being the case, it is not surprising to find, from an official report, that "sentry duty in the night, from the exposure to the influence of malaria, is no doubt the principal cause of fever at Kamptee."‖

Further, the prevalence of fevers at Jacobabad and other places, already referred to, shows that intense malaria coexists with extremes of heat and cold even in the absence of marshes, vegetation, or any supposed sources of poison. On the other hand, it is especially worthy of notice, that places, which are found to be remarkably free from paludal fever, though presenting all other characteristics of the most malarious localities in the same latitudes, are remarkable for the mildness and equability of their climate; and differ in this respect only from the most unhealthy regions.

* *Madras Topographical Reports*, 1844.
† *Army Medical Report*, 1865.
‡ *Ibid.* 1866. § *Ibid.* 1867.
‖ *Report of Royal Commission on Army in India*, ii. 371.

Ireland, Singapore, and the valley of the Amazon, have been already alluded to by me; they are each mentioned by other writers, as remarkable exceptions to the general presence of malaria in swampy districts. Occurring, as these instances do, so far apart and in such different climates, no great similarity is likely to be met with in soil, water, or vegetation; nor does it exist. In one respect, however, these places are alike; each is remarkable for the great equability of its climate. And in no important point, but this, do any of these healthy districts differ from others in which malaria abounds.

The climate of Ireland is remarkable for its moisture and equability,—for the extreme mildness of the winter, and the low temperature and clouded sky of summer. Owing chiefly to the proximity of the gulf stream, these characteristics are most marked in the west; where the rainfall is greater, and the climate milder, than towards the east coast. Dr. Lloyd, quoted by Professor Tyndall, says, that the mean yearly temperature of the west is 2° higher than that of the east coast, in the same latitude, and at the same elevation.* Yet, even in the eastern districts, the mildness of the climate is very remarkable. Humboldt observes: "In the north-east of Ireland, lat. 54° 56. lying under the same parallel as Konigsberg, the myrtle blooms as luxuriantly as in Portugal. The mean temperature of the month of August, which in Hungary rises to 70° F., scarcely reaches 61° F. at Dublin, on the same isothermal line of 49° F. The mean winter temperature, which falls to 28° F. at Pesth, is 40° F. at Dublin; 3°. 6 higher than that of Milan, Pavia, Padua, and the whole of Lombardy, where the mean annual temperature is 55° F."†

Ireland, as every one knows, is famous for its extensive bogs and marshes, and its rich pastures; while vegetation is no more exempt from the universal law of death and decay, in that country, than it is elsewhere. Yet, as I have already mentioned, malaria is very rarely met with and, when it does occur, it is generally on the east coast. In the west,

* *On Heat*, vi. 171. † *Kosmos*, vol. iii. 329, 331.

the "marsh poison" is equally uncommon on bog and on grass lands.

Malaria has on some occasions, however, been prevalent in Ireland; in 1829—30, especially, the hospitals were full of intermittent. The nature and position of the bogs having undergone no material change, why should there have been this explosion of malaria? It seems that the year 1828—9 was hotter than any of the five previous years, while the year 1829—30 was colder than any of the twelve previous years.* Thus, a great degree of cold followed unusual heat. Moreover, just before the period referred to, typhus had been epidemic throughout Ireland, showing a generally low state of vitality amongst the poorer classes; and this, also, may have had some influence in causing the unusual prevalence of malarious fevers.

Taking all the circumstances together, it seems tolerably certain, that in the climate, rather than in any peculiarity of the bog vegetation, is to be sought the great freedom of Ireland from malaria. This, too, appears to be confirmed by the fact, that rotting flax, (to which no one thinks of assigning any antiseptic or antimalarious properties,) is in Ireland, at all events, perfectly harmless.

The settlement of Singapore, hot and moist, surrounded by salt marshes, and a profuse tropical vegetation, might be expected to be a hot-bed of "paludal poison;" but far from this being the case, it is, as I have already observed, noted for its exemption from malarious fevers.† The explanation of this is to be found in the extraordinary equability of the climate. We are told, that, "from the temperature being so uniform throughout the year, Europeans are remarkably exempt from the sudden and severe attacks of disease, so common in Hindostan; but, owing to the absence of a cold season, the climate is not well adapted to men, who are much reduced in health and strength."‡

This shows that a climate may be hot, moist, and the reverse

* Glaisher, *Thermometrical Observations of the Royal Society.*

† *Report of Roy. Commission on Sanitary State of Army in India.* ii. 597.

‡ *Ibid.* ii. 595.

of invigorating, and yet malaria be, under ordinary circumstances, almost entirely absent. In the year 1859, at Singapore, the highest mean monthly temperature was, in July, 82° 5 F. and the lowest, in January and November, 80° F.*

A more equable climate, than this, could scarcely be found; and in this lies the secret of the great freedom of the settlement from malarious diseases. This is confirmed by the fact mentioned in the report just quoted, that "when an unusual fall of rain takes place, at the beginning or end of the year," or in other words, when the temperature is lowest, intermittent fever sometimes makes its appearance. Heavy rain even here, as in all equatorial regions, produces a certain degree of cold.

The swampy, forest-clad tract on the banks of the Amazon, (to which I have already referred as being singularly free from malaria,) is contrasted, by Humboldt, with the hot, humid, and unhealthy regions on the banks of the Orinoco and Magdalena; where the influence of the trade wind is not felt. That writer observes: "In the corresponding part of the valley of the Amazon, at the same distance south of the equator, a strong wind always rises two hours after mid-day, blowing constantly against the stream; with this wind you may go up the Amazon under sail from Para to Tefe, 750 leagues. At the foot of the Cordillera, this Atlantic breeze rises sometimes to a tempest. It is highly probable, that the great salubrity of the Amazon is owing to this constant breeze."†

The tendency of this strong wind from the Atlantic, blowing with greatest force at the most sultry season and during the hottest hours of the day, is, I need scarcely say, to render the climate mild and equable.

Bates mentions, that on the Amazon, "the decrease of temperature at night is never more than a pleasant coolness;" and says that "the water is generally warmer than the air."‡

* *Report of Royal Commission on Sanitary State of Army in India*, ii. 595.

† *Narrative of Travel*, xxi. 314, 315.

‡ *Naturalist on the Amazons*, vii. 163.

The branch rivers are however unhealthy; owing to the direction of their course, the sea breeze is not felt; their banks are in general higher and drier than those of the main stream; and the air is hot, sultry, and stagnant by day, and chill and damp by night.

On the Tapajos, Bates observes: "The mornings, for two hours after sunrise, were very cold; we were glad to wrap ourselves in blankets, on turning out of our hammocks, and walk about at a quick pace in the early sunshine. But in the afternoon the heat was sickening."* And he adds: "I began now to understand, why the branch rivers of the Amazons were so unhealthy; whilst the main stream was pretty nearly free from diseases arising from malaria."†

In another place, the same traveller says: "Notwithstanding damp and mosquitos, I had capital health and enjoyed myself much at Fonte Boa; swampy and weedy places being generally more healthy than dry ones, on the Amazons, probably owing to the absence of great radiation of heat from the ground."‡

* *Naturalist on the Amazons*, ix. 251. † *Ibid.* ‡ *Ibid.* xiii. 438.

CHAPTER XI.

CHARACTERISTICS OF MALARIOUS SITUATIONS.

Two classes of malarious localities—Nightly chill the one condition common to both—In hot or in cold climates, dank night air most prominent characteristic of marsh—This disappears by day—So does malaria—Same thing occurs in other unhealthy situations—Damp localities generally malarious—But not in proportion to the degree of humidity—Damp not malaria—Moisture exaggerates effect of cold—In variable climates malaria often diminishes in rainy season, the temperature becoming more equable—Aqueous vapour and its influence upon climate—Professor Tyndall's observations—Effects of damp very important in connection with irrigation—Excessive irrigation known to cause deadly malaria—Instance in India—Author's observations—Evil effect least apparent in a hot and equable climate—Rice cultivation produces malarious disease in the north of India, but considered harmless and even beneficial in the south—Dr. McPherson's remarks—Palaveram—Major-General Cotton's experience—Dr. Saunders on the fever in lower Bengal—Night exposure in a moist climate, with insufficient protection from chill, liable at any season to produce fever.

In confirmation of what I have advanced, it is to be observed, that malarious situations may be divided into two classes, viz.

1. The wet or marshy.

2. The more or less dry, in which absorption and radiation of heat are excessive.

The latter group can of course only exist in hot climates, where the influence of the sun is very powerful. Accordingly, in cool climates, malaria is seldom found except in wet or marshy places; the variations of temperature requiring, as already observed, to be supplemented by the powerfully chilling influence of moisture.

All malarious localities, to whichever of these groups they belong, have one condition in common and, so far as can be traced, one condition only, viz. a sudden and considerable lowering of temperature at sunset; the effect of which, on those exposed to it, is often heightened by a copious dew or a cold wind. In all cases, malaria is most active at night; and, in most situations, this is the only time at which it exists.

Most writers agree, that the "paludal poison" exists in marsh air.

Apart from the stagnant water and decomposing vegetable matter, which, as I have shown, do not always exist in malarious localities, what is the most prominent characteristic of marshes, either in hot or in cold climates? Is it not the dank chilly atmosphere, so well described as "aguish," which, always found in such places at night, disappears by day under the influence of the solar rays?

Again, in the dry bed of a river or torrent, on the sandy plain, lately inundated but now dry, or on the low, flat, oozy beach, little or no vegetation exists. What then, have these in common with the marsh, but a raw, humid atmosphere at night? This they have in common, also, with the moist alluvial delta, the slowly drying swamp, over irrigated fields, and undrained clayey land. It is in this, that they all differ from healthy places.

The dense forest, when wet and swampy, has the same characteristics as the marsh; when dry, it is not more unhealthy than other places in a similar climate.

The arid rock, unsheltered by trees or vegetation from the rays of a tropical sun, appears to have little in common with the fen, except "malaria;" but here, too, the temperature falls rapidly at night; and though the sensation of cold may not perhaps be so keen as in the swamp, the heat by day is so intense, that the variation is very great. The one condition, therefore, common to all the various situations in which malaria prevails, is a considerable fall of temperature when the sun's rays are withdrawn; and in most cases this cold is combined with moisture, by which its effects are intensified.

Damp situations are almost everywhere malarious, though, as I have already shown, this is entirely irrespective of the presence of vegetation, living or dead. Whatever the source of the moisture may be, whether a marsh, a swampy forest, or a soil saturated, by unseasonable rain, by excessive irrigation, or by deficient drainage, the effect produced is almost always the same, viz. a damp chilly atmosphere at night.

Excessive humidity may render a comparatively healthy

country pestilential, as is to be seen in the history of extensive inundations, in every quarter of the globe. But, as I have already mentioned, some very wet and marshy places, in different parts of the world, are very free from malaria. Other damp localities, moreover, are not all equally malarious, nor are they unhealthy in proportion to the degree of moisture; if they were so, few climates would be more deadly than that of Ceylon, while lower Bengal would be uninhabitable. Fevers, too, are not always most prevalent, at the seasons in which humidity is greatest; as, except in equatorial countries, they generally prevail most after the rains have ceased. Moreover, as I have already shown, malaria is often most intense when a marsh is drying up; and even prevails in very arid places.

Damp, then, is not malaria; though so intimately associated with it. Something more is required to produce malarious disease; and this is found in chill.

In upper India, where the variations of temperature are great, a degree of moisture in the soil, less than that which is habitual all over lower Bengal, is sufficient to produce severe epidemic fever. This exaggeration of the evil effects of damp, in Northern India, is however only felt when it is combined with nightly cold; for a much greater degree of humidity, at the time of the usual rainy season, does not cause epidemic sickness: the climate then being mild and equable. For the same reason marshes, when flooded *in the rainy season*, are often less noxious than at other times, and are especially dangerous *when the rains have ceased*, and they are drying up.

In the hot and equable climate of Demerara and Surinam, where the atmosphere is very moist, and the rainfall great, the planters live, as mentioned by Fergusson and others, close to swamps, which, though far from healthy even there, would in most countries be deadly.

This immunity from malaria, which it must be observed is only comparative, is due to the diminution of nightly chill, owing in a great measure to the constant humidity of the atmosphere. "No doubt can exist," observes Professor

Tyndall,* whose researches have thrown so much light upon this action of aqueous vapour, "of the extraordinary opacity of this substance to the rays of obscure heat; particularly such rays as are emitted by the earth after being warmed by the sun." On the other hand, as observed by the same writer, "the refrigeration at night is extreme when the air is dry."

Hence it is possible, with a moist atmosphere, to live on the borders of swamps, which in a drier climate would be pestilential. Hence, too, the great diminution of terrestrial radiation during the rainy season, and the consequently diminished production of malaria, which then occurs in marshy spots, as well as the increased activity of this cause of disease when the rains have ceased and swamps are drying up.

In the dry season, the night air of marshy places is, to a slight elevation, excessively humid, but the atmosphere above and around is comparatively dry; there is, consequently, no efficient check to nocturnal radiation, although, near the ground, the condensed moisture is amply sufficient for the rapid abstraction of heat from animal bodies exposed to it.

For the reasons just given, the universal humidity of the rainy season, when both air and soil are saturated with moisture, is comparatively harmless. But with a drier atmosphere and a drier soil, when a sufficient degree of dampness remains to intensify the effect of nightly cold, we have the widespread malaria of autumn, which is, in hot climates, by no means confined to marshy spots. From what has been said, it will be apparent that a degree of humidity of soil, which may scarcely be injurious in the hotter, moister, and more equable climates of Bengal or Southern India, is sufficient to cause pestilence in the chilly autumnal season of the more northern provinces.

Closely connected with the consideration of the effects of damp, is that of the influence, upon the public health, of artificial irrigation. This subject is one of vast importance in a country like India, over a great part of which, cultivation is impossible without this means of supplying moisture

* *On Heat*, xi. 366.

to the soil; where, too, works for this purpose, on a very large scale, have long existed, and many others are in process of construction.

It is well known that, in Northern India, excessive irrigation of any land, however highly cultivated it may be, will produce malaria as deadly as that of the most poisonous swamp.

This was shown in the case of the Western Jumna canal, which, constructed originally in Mahomedan times, exhibited several defects such as have been avoided in more modern works. Here, with a liberal supply of water, cultivation extended; the fertility of the land increased; and the proprietors became rich. But adequate provision had not been made for drainage. In consequence, the level of the springs rose; the ground became saturated; the country acquired the character of a swamp; the people became a miserable set of fever-stricken wretches; and it was found necessary to abandon the large military station of Kurnal, owing to the sufferings of the garrison from malarious disease. In this instance, the effect produced artificially was exactly what existed naturally at Walcheren, Wilmington, and other places, which I have mentioned, viz. the permanent saturation of the subsoil; and the results in each case were similar.

Some years ago, when officially connected with the Baree Doab canal, one of the largest irrigation works in Northern India, I gave a good deal of attention to this subject; which interested me the more, as I was, at that time, trying to solve the question propounded at the beginning of this work. The result of my observations, which agreed with those of Engineer officers of great experience in these operations, shewed that there is little fear of malaria being produced by irrigation, in any district, so long as the supply of water is not greater than can be readily absorbed by the soil, and the surplus is carried off by an effective system of drainage, or by the natural configuration of the country. But, when the supply is in excess, and the ground remains saturated, malaria is the result; whether the land be cultivated, or uncultivated, covered with jungle, or perfectly bare, and whatever may be the na-

ture of the soil. In fact, I was convinced that damp is to be feared, and not the development of any specific poison.

But, as I have already observed, in a hot and equable climate the ill effects of moisture are not nearly so apparent.

For instance, rice cultivation, in Northern India and in many other countries, is well known to cause malarious disease, not by any specific action of the crop upon the soil, but, from the quantity of water, necessary for its cultivation, reducing the land to the condition of a swamp. In Southern India, on the other hand, not only is the cultivation of this grain considered harmless; but in some instances, where the climate is equable, and the heat is very great, the reduction of temperature, produced by covering a large surface of country with water, is considered to improve the health of the locality.

Deputy Inspector General Dr. McPherson remarks, that at Trichinopoly, "by means of artificial irrigation from the river Cauvery, the cultivation of rice is brought close up to the station; but this does not appear to exercise a prejudicial effect upon the health of the troops. Indeed it has been observed, that a marked change for the better takes place in the climate of Trichinopoly, when there is a sufficient supply of water to cover the face of the country."*

An official report from Palaveram, on the Coromandel coast, states: "The healthiness of the neighbouring native population is attributed to the fact of their being principally employed in the cultivation of rice." But here, it is to be observed, "the heat is very great all the year, there being no cold season."†

It has been remarked by the officers of the Madras irrigation department, that the tracts in which rice is most extensively cultivated are often the healthiest of those traversed by their canals; these districts, however, are near the sea coast, and their climate is hot and very equable.

Major-Gen. Cotton, R. E. observes: "In Southern India we know nothing of ill effects to health from irrigation."

* *Report of Royal Commission on Sanitary State of Army in India.* ii. 624.
† *Ibid.* ii. 400–401.

And again: "Our experience led us to suppose that excessive and continuous heat made countries more safe from fever."*

In further proof of what I have said, as to excessive dampness being least injurious, in proportion to the equability of the climate, and to the degree of protection from the effects of chill, I may quote the following remarks from a report by Deputy Inspector General Dr. Saunders, of the Bengal army, on the fever in the dank and swampy Hooghly district of Bengal:—"During the rainy season large portions of each Zillah† are submerged, an immense cultivation is carried on in the inundated districts, (rice) which, consuming as it does, the decaying animal and vegetable matters existing in the soil, aids the inundation in keeping down noxious exhalations. During these months, moreover, the meteorologic changes, which are everywhere observable, are less marked than they are at other seasons of the year; it is true the rainfall is considerable, but the extremes of temperature are not excessive, the daily range of the thermometer being about 5 to 8 degrees. We consequently find that disease is not then so prevalent in the province, as it is later in the season; but when there is a considerable daily range of the thermometer, great variation in the humidity of the atmosphere, and great evaporation going on from the soil, with a *certain amount of actual cold*, then we have in full operation all those common, but active influences, which produce disease; and the rural population suffer at once, from insufficient clothing and diet, as also from the climatic peculiarities, which I have just indicated. Fevers then are rife, accompanied in nearly all cases by visceral congestion, principally of spleen and liver, but occasionally of lungs, and frequently of articular structures. These fevers continue to prevail in November, December, January, February, and March; when the *hot season sets in*, and the poor destitute Bengalee experiences as much of health, as his low state of vitality will permit."‡

* *Report of Royal Commission of Sanitary State of Army in India*, i. 126.

† District.

‡ *Indian Med. Gazette.* Oct. 1869.

In those low, moist, equatorial countries in which there is no approach to a cold season, except during the period of violent storms and heavy rain, the development of "malaria," then, becomes most active; but, even there, the beginning and end of the rainy season, when the daily variations of temperature are greatest, are more unhealthy than the middle of it, when the climate is somewhat more equable.*

It must be borne in mind, however, that although in humid and sultry climates, malarious disease is most prevalent at the coldest season; so great is the heat-abstracting power of damp, that, in case of insufficient clothing or shelter during the night, chill, and consequent fever, may result at any period of the year.

On the low and swampy west coast of tropical Africa, where the heat by day is intense, such is the effect of moisture in abstracting animal heat when the influence of the sun is withdrawn, that blanket clothing is necessary for those who are exposed at night.† Throughout the tropics, chill produced by exposure to rain, even in the daytime, is a frequent cause of fever.

* *Vide*, p. 18, 19.

† *Naval Medical Report*, 1865, p. 187.

CHAPTER XII.

CHARACTERISTICS OF MALARIOUS SITUATIONS (Continued).

Malaria, its latency by day and energy by night incompatible with its being an organic poison—Exists in swamps, deserts, and in mountainous regions—Exhalations from marshes consist of aqueous vapour only—Are innoxious during the day—At night, chill and malaria come together—Night air not malarious when dry and warm—Sleeping in open air in hot climates—Intensity of malaria in low situations and feebleness at slight elevations—Wells' observations—At night, the coldest strata of atmosphere nearest the ground—In hot climates, malarious disease occurs at great altitudes—The hotter the climate, the greater altitude necessary for safety—Instances of malaria on mountains—Line of malarious influence imaginary—Malarious season varies with altitude and climate—Safety from malaria at great elevations limited to those who are well sheltered and well clothed—Sickness in newly occupied situations often depends upon undue exposure to climatic influences.

The latency of malaria by day, and its energy by night, are totally irreconcilable with the supposition of its being an organic poison.

If malaria were generated from decomposing organic matter in marshes, or in the soil, it would be most powerful at the time of its generation, as well as at the spot in which it is formed; consequently, it would be most deadly, not only near the surface of the ground or swamp, but also during the greatest heat of the day, when exhalation is most active.

Even if, as some writers have assumed, the malarious emanations becoming rarified by solar influence, are, during the day, carried into the atmosphere with ascending currents of heated air; there must be a period before they become diffused in the atmosphere, and at this time they must exist in their utmost intensity. The process of exhalation, moreover, must be continuous and the supply of poison, therefore, unfailing throughout the day. Yet, at this very time, the most pestilential swamps may be visited with impunity. Sportsmen may, even in India, wade all day with safety through fœtid mud and stagnant water; although at night the same places become deadly from the effects, as is supposed, of the same poison, in a stale condition, which was being given off, in all its freshness, during the time of their visit.

After the dispersal of a specific miasm for a whole day in the atmosphere, no condensation by evening cold could produce an activity equal to that possessed by it, at the time and place of its development; nor is it possible, that the malarious emanations could always return at night to the exact spot from which they set out. Again, supposing that the "malaria" returns from the higher atmosphere, under the condensing power of nocturnal cold, coming from above, how is it that a few feet of elevation is often a security against its effects?

When, in addition to the foregoing considerations, it is found that the nightly energy of malaria and its quiescence by day are not confined to the neighbourhood of marshes, or even of vegetation, but are equally constant in sandy deserts and amidst barren rocks; it becomes tolerably clear, that some other explanation, than that hitherto proposed, must be sought for its mysterious nocturnal habits.

When, however, we consider that the noxious exhalations from marshes consist of aqueous vapour only, it becomes easier to explain why a poison which is so potent by night, is powerless in the same spot while the sun is up.

During the day, the watery vapour given off by the swamp, under the rarefying influence of the solar rays, rises into the atmosphere, its presence is imperceptible, and its injurious properties are neutralised by the heat. Then, there is no malaria. But, as soon as the rays of the sun are withdrawn, condensation takes place, and the hitherto invisible vapour is transformed into mist or dew; the air becomes damp and chill; and malaria is the result.

Hence the night mists, so constantly alluded to in descriptions of malarious localities, (of which we have an example in the dreaded "Awal" of the Terai,) and the heavy dews so general in the same situations.

When to all this is added the fact, that those who suffer most from malarious disease are the imperfectly sheltered, and insufficiently clad, those who lie on the wet ground, or suffer from hunger and fatigue; in short, those most exposed to, and least able to resist, the effects of damp and chill, the nightly energy of "malaria" is no longer mysterious.

Mist, though so frequently present at night in marshy places, is not essential to the production of malarious fevers; as these may appear where it does not. Dew, however, which is a more universal consequence of nightly cold, is a much more constant attendant upon "malaria," and has been in all countries, and by almost all observers, associated with it.

In addition to the foregoing, it should be observed, that exposure to night air, although so dangerous if the atmosphere is damp and chill, is attended with little risk, even in the same localities, when it is warm and free from moisture. In the plains of upper India, sleeping out of doors is attended with but little danger, even for Europeans, in the dry, hot months; although, at other seasons, fever would be a probable result. The refreshing sleep, which is often obtained in the open air, when rest is impossible in the stagnant atmosphere of a house, is so beneficial as, at that season and in that climate, to far outweigh all risk from "malaria."

In the western part of the Punjab, and especially about Mooltan, and in the Dera Jat, where the heat is for some time very great throughout the night, to sleep out of doors is a common practice amongst the white population. It is, however, only safe to do so, in the hot and dry season, when there is little difference between the daily and nightly temperature. Such exposure, when the earth has been moistened by rain, when the nights are chill and dew is formed, is most likely to be followed by fever. In the more humid climates of Bengal or of Southern India, exposure to night air is, at all times, attended with considerable risk; although there, as elsewhere, to sleep in a tent, in an open verandah, or even under a spreading tree, is often comparatively safe, when to do so in the open air, under a cloudless sky, exposed to dew and rapid radiation of heat, would be almost certain to cause fever.

Amongst the natives of India, the habit of sleeping out of doors is almost universal in the hot season; but no man will do so if he can help it, either on the top of his house or on the ground, while rain is falling, when the atmosphere is very damp, or in the cold months.

Dr. Dempster mentions that the principal Hakeems, or native physicians, of Peshawur, in reply to the question: "Is it necessary to health, to avoid sleeping on the ground-floor at particular seasons of the year?" said: "During the very hot weather, it is proper to sleep in the open air, on the tops of the houses; at all other seasons people sleep below. It is dangerous to sleep on the tops of the houses in the months of October and November."*

It should be observed, that in the months named, bleak night winds prevail, the heat, for some time previous, having been intense. It is the nightly cold that renders it dangerous, at this period, to sleep on the tops of the houses at Peshawur.

Malaria, then, is only present in night air, when the latter produces a chilling effect upon those exposed to it.

Inseparably connected with the nocturnal energy of malaria, are its existence in a most intense form in low situations, and close to the surface of the ground, and its feebleness at a slight elevation above it; points very strongly urged by almost all authorities on the subject. "The specific gravity of malaria," says Dr. Pickford, "is considerably greater than that of the atmosphere.† "Malaria," says Sir T. Watson, "loves the ground. It tends downwards."‡ Other writers have made similar observations. Many instances are quoted of safety, from the influence of malaria, having been secured by sleeping at an elevation of a few feet above the ground; and the advantage of doing so is recognised in all malarious regions. In Burmah, Assam, and other similar marshy countries, the people build their houses on posts. Wallace mentions, that the houses in New Guinea were elevated at least 15 feet above the ground, upon a complete forest of poles.§

The Guaranos Indians of the Orinoco live in trees,‖ and so do other savage tribes inhabiting swampy countries.

* *Report of Royal Commission on Army in India.* i. 470.
† *Hygiene*, p. 169.
‡ *Practice of Physic.* i. 763.
§ *Malay Archipelago.* xxxiv. 309.
‖ Humboldt. *Narrative of Travel.* ix. 297.

Although, the cause of malarious disease prevails in its most intense form near the surface of the ground, and especially in low situations, and becomes comparatively feeble at a slight elevation above the soil; it also exists, and in the same countries, on the summits of lofty mountains many thousand feet above the sea. And there, as in the plain, it is most virulent by night.

What then, can this poison be, which attains with difficulty an elevation of a few feet above the soil, yet against which, the altitude of the Himalayah is an insufficient protection; which is heavier than the dense atmosphere of the swampy plain, yet able to sustain itself in air so highly rarified as that, at an elevation of 8000 or 9000 feet?

A consideration of the effects of terrestrial radiation furnishes a solution of this problem.

Wells, in the course of his experiments, in connection with the formation of dew, found that, on a clear calm night, the mercury of a thermometer, laid on the grass in a field, sank as much as 14°, and on one occasion even 15°, lower than that of another, suspended in free air at a height of four feet above the ground.*

This important fact, at once, explains the preference of malaria for the surface of the ground, whether on a plain or on a mountain side, and furnishes a clue to the cause of its nocturnal intensity. For by day, no such difference of temperature exists; in fact, the condition is reversed, and the heat, near the ground, is greater, than at a short distance above it.

When the sun's rays no longer heat the earth, the surface of the latter, from the rapid radiation of its heat, cools rapidly. The lower strata of the atmosphere, therefore, soon become chilled, and remain colder than those above them.

Moreover, not only is the temperature so much lower near to the ground, than at a very few feet above it; but, the greater the degree of cold the more complete is the condensation of the aqueous vapour suspended in the atmosphere, so that near the surface of the earth this becomes mist or dew.

* *On Dew.* p. 26, 120, Casella's Ed.

Further, the denser the moisture the greater is its power of absorbing heat, and, consequently, of abstracting it from the human body. In the night, therefore, a man at the level of the ground, is not only exposed to the coldest stratum of chill and humid air, but his clothing and everything around him are saturated with dew. On the other hand, a man, at a few feet of elevation, is raised above the coldest and dampest portion of the atmosphere and placed in one both warmer and drier; while, should the air around him become chilled, it sinks to a lower level.

Loss of heat by radiation, condensation of moisture, and a higher temperature at the distance of a few feet above the surface of the earth, all occur, though not in an equal degree, at the level of the sea and at the greatest elevations. In every case, however, these conditions appear by night, when the sun's rays are withdrawn; and, from several causes, depending upon the more intense degree of solar heat, they are often very much more active in hot climates, than in England, where Wells made his experiments.

Comparative safety having been, for the reasons just given, secured, in cool regions, at a slight elevation above the level of a swamp, it has been commonly supposed, that certain degrees of altitude secure immunity from the effects of "marsh poison." But, a more extended observation has shown that, in hot climates, "malaria" may, as I have already mentioned, exist at very great heights.

There is no doubt that, in the tropics, the climate becomes more salubrious as we ascend, that is, as it becomes cooler and more invigorating. It is owing to this, and to the means they furnish for escape from the predisposing influence of excessive heat, that mountain heights, in hot countries, afford so much protection from malarious disease. That this is the case is shown by the facts, that the hotter the climate the higher is the altitude necessary to secure freedom from the influence of malaria, and, that until a cooler climate be reached, no safety is to be obtained. Low ranges of hills are often hotter by day, and at the same time more intensely malarious, than the neighbouring plains.

That malarious fevers are often very deadly at considerable elevations, may be gathered from the following instances:—

"About 25 miles east of Quilon, is a lofty range of hills, separating Travancore from Tinnevelly, the summits of which, are between 2000 and 3000 feet above the sea; they are covered with thick jungle. The period of the rains, and immediately after, is the only time when it is believed, that these hills can be visited with impunity, especially by Europeans; as passing even a single *night* on them, between the months of February and June, produces fever of a dangerous and fatal character, almost to a certainty."*

"In Madura, a chain of hills, taking a north east course, divides the Polliums from the Dindigul valley, and extends for more than 20 miles, as far as Cottamputty, on the road from Madura to Trichinopoly. These hills are feverish, during the months of February, March, and April, and sometimes even in May. On some of the lower hills also, fevers prevail at the same period."*

Of the Pulney hills, from 2500 to 7000 feet above the sea, Inspector General Dr. Pearse observes: "The higher ranges are decidedly salubrious, and the inhabitants are a robust and healthy people. The most unhealthy seasons with them, are the cold months, when coughs, colds, and occasional fevers from exposure, are met with."

"In the lower ranges to the east, from March to July, it is decidedly unhealthy; the inhabitants, there, suffer much from fevers; enlargement of the spleen being also common."†

Malarious fevers occur on the tablelands of Mexico, at an elevation of 2000 metres‡ (upwards of 6000 feet); in Peru, and in Central America, at about the same altitude; and I have met with them, in the Himalayah, at an elevation of between 8000 and 9000 feet.

Both remittents and intermittents arise at every hill station in India. Dr. Chevers alludes to the existence of these dis-

* *Madras Topographical Reports.* 1843.

† *Report Royal Commission on Sanitary State of Army in India*, vol. ii. 613.

‡ Jourdanet, *Les Altitudes de l'Amerique Tropicale*, p. 260.

eases at Simla, upwards of 7000 feet above the sea.* Dr. Farquhar, in his official report on the Mussoorie sanitarium, for the year 1862, mentions the occurrence of 13 cases of remittent, and 190 cases of intermittent fever, between March and November, in that year; the greatest number of cases, being in the rainy months of August and September.† This was in lat. 30° N., at an altitude of 7000 feet; there was no trace of marsh in the neighbourhood; and many of those attacked, being permanent residents of Mussoorie, could not have carried up the seeds of disease from the plains.

At Nynee Tal, 6400 feet above the sea, "intermittent fever, with enlargement of the spleen, and variola, are the diseases most prevalent amongst the native population."‡ And "intermittent is the prevailing disease, in wet seasons, from June to August."‡

At Dalhousie, the higher portion of which is at an altitude of 7800 feet, intermittents are common, and remittents are not unknown. Both are most prevalent during wet seasons, and amongst the native servants and other natives from the plains, who are very sensitive to the cold, and seldom sufficiently protected from its effects; being thinly clad and often very badly lodged. The warmly-dressed, and well-housed white population suffer but little from these fevers.

Absolute safety from malaria does not appear to be obtainable at any altitude; but, everywhere, the cooler and more equable the climate the less it is to be feared, at all events by the white race. The so-called line of malarious influence is a purely imaginary one. The prevalence, or otherwise, of malarious fevers depends, not upon elevation, but upon climate; and is liable to constant variation, from thermal and other causes. Thus, in the higher ranges, fevers are most prevalent during the rainy season; but in the lower ranges, they become rife at such times as they are most prevalent in

* *On the Health of European Soldiers in India.* Ind. Ann. Med. xi. 1859, p. 285.

† *Indian Ann. Med.* No. xvi. 1862.

‡ *Report Royal Commission on Sanitary State of Army in India.* ii. 199.

the neighbouring plains, as, when a period of unusual heat is followed by sudden cold. In mountainous regions, as in other places, both the frequency and the severity of malarious fevers are governed, to a great extent, by the degree of exposure to climatic influences. In the Sâl forests of the plateau of Amarkuntuk, some 3000 feet above the sea, the heat is great by day, but the nights, throughout the hot season, are humid and chilly, and the dews very heavy. At this season, the natives, (herdsmen, woodcutters, and others,) with insufficient clothing and bedding, and very indifferent shelter from the moist cold air at night, suffer very severely from fever. At the same time, European officers with good tents, bedding, and clothing, find the climate refreshing and invigorating. In fact, in the words of my informant, an officer well acquainted with the district, a visit to these forests, in the hot season, was to him almost like a trip to "the hills." The native servants of this officer escaped fever, but they were well protected from cold and damp.

In these forests, the rainy is more unhealthy than the hot season, for the variation of temperature is then still greater. Annesley mentions, that in the neighbouring hilly district of Sirgoojah the range of the thermometer, during the rainy months, is upwards of 70° in the 24 hours; and that it is nearly the same in Sumbulpore,* which is at no great distance.

It is evident, from the foregoing facts, that the comparative immunity from the fevers of tropical climates, which is secured at great altitudes, is mainly owing to the absence of that great heat which predisposes to malarious disease. But it is also clear, that the safety alluded to, is, in a very great degree, limited to those who are properly protected from sudden vicissitudes of temperature, and in some measure also, to the natives of cool climates.

Hence may be seen the importance, in estimating the healthiness or otherwise of any locality, of considering the effects of climatic influences, rather than of speculating upon the presence or absence of a hypothetical poison. There can

* *On Disease of India.* Vol. i. 130.

be no doubt that many experiments with regard to the salubrity of hill stations have failed, not only from injudicious selection of sites, but also from undue exposure of those sent to make the trial, the results of which have been ascribed to "malaria."

CHAPTER XIII.

FURTHER CHARACTERISTICS OF MALARIOUS SITUATIONS CONSIDERED.

Water said to absorb malaria—this statement examined—Ships lying off a malarious coast comparatively safe—Explanation—Malarious fevers occur at sea—Instances of this—Influence of winds upon malaria—Winds beneficial when of equable temperature and force—S.E. tradewind—Cold winds dangerous in hot climates—N E. Monsoon—Pringle's remarks on cold night winds—Livingstone's case—Remarks of Drs. Dick and Vans Best on Stanley. Hong Kong—Cold winds dangerous in mountain gorges—Instances in India—Dr. A. Smith, on night winds at Payta.

It has often been asserted, and with some apparent ground, that malaria is unable to pass a moderate expanse of water. Sir T. Watson observes: "It is a singular, but well-ascertained fact, that the miasmata lose their noxious properties by passing over even a small surface of water."*

The safety of the crews of the ships stationed in the narrow channel between Walcheren and Beveland, in 1747, when the troops on shore were suffering severely from fevers, as mentioned by Pringle; and of the troops remaining on board the transports at the time of the Walcheren expedition, in 1810, only three quarters of a mile from land,† are cases in point. It is well known, too, that ships, in the centre of a river or harbour, are safer than those near the shore.

The protection against malaria thus afforded, by a body of water, has been ascribed to the absorption of the poison by that fluid. But this idea is wholly untenable, otherwise, water should have the same power of absorption in swamps or lagoons, as in any other situation, and malaria should disappear from such places at the moment of its birth; moreover, moated towns, forts, and other positions surrounded by water should always be safe, which they very rarely are.

An ordinary stream or canal does not seem to have any power to arrest the course of malaria; nor does a shallow

* *Practice of Physic.* i. 766.

† Hennen, *Medical Topography of Mediterranean.* 212.

lagoon, however broad, appear to have much. Frequently, in the centre of the great African rivers, fevers are almost, if not quite, as deadly as on shore. The fatal Niger expedition affords an instance of this, and, in the case of an expedition up the same river last year (1869), the crew of H. M. S. Lynx who were left on board the ship, which was at anchor in the stream, were attacked with fever before the party who were on shore; though the latter had to wade through swamps, breast-deep in mud and water. The crews of ships are often attacked with fever in the large rivers of Burmah, and in the Hooghly; and the same thing is noticed in most navigable streams and in almost all harbours, in the tropics.

It is evident, therefore, that water is not impassable by malaria and does not absorb it. There can be no doubt, however, that ships lying within a very moderate distance of a malarious coast, even within the influence of the land breeze, are comparatively safe; and very much more so, than they would be at the same distance from the shores of a shallow river or lagoon. This arises from causes, which will be explained by a consideration of the following facts.

In the river or lagoon, the ship must necessarily, at night, be exposed, more or less, to the influence of terrestrial radiation, the effects of which have been already referred to, and to damp, cold winds from the land by which she is almost surrounded. A ship lying off the coast, on the other hand, is protected by the mild and healthy sea breeze blowing from the opposite direction. Further, the waters of a shallow river or lagoon are readily heated by day and rapidly cooled by night; when, the watery vapour of the lower strata of the atmosphere becoming condensed, the air is chilly and humid as that of a marsh. The depth and volume of the ocean, on the other hand, render any material change in its temperature impossible; the chilled water sinking, and its place being constantly taken by portions, of that which is warmer, rising from below. In short, the more shallow the water, the greater are both the daily heat and the nightly cold.

The large and constant quantity of aqueous vapour, in the atmosphere over the ocean, also contributes to the equability

of the temperature, by diminishing nightly radiation of heat. For these reasons it is apparent, that the value of water, as a protection against malaria, must be in proportion to its depth and volume; as well as to distance from shore, and consequent diminution of the chilling influence of terrestrial radiation. Hence, a lake is a greater safeguard against malaria than a swamp; and the open sea, than a shallow lagoon. The fact, too, of the more rapid chilling of the earth, than of a body of water, will explain why, at night, the shore of a lake is more dangerous than the centre, the banks of a river than the middle of the stream, and the vicinity of a coast than the open sea. Taken in connection with the predisposing influence of great heat, already referred to, this will also explain why the distance from land, necessary to ensure comparative safety from malarious disease, is greater in hot, than in cooler climates.

Although, for the reasons just given, malarious fevers are much more rare at sea than on shore; they do occur even in mid-ocean, especially in the tropics, and generally in wet and stormy weather.

Sir J. McGrigor mentions, that the Bombay native troops, on their way to Egypt to join the expedition under Sir David Baird, suffered very severely from remittent fever on board ship; and that the sickness left them as soon as they landed.*

It may be observed, that black troops often suffer severely from malarious fevers, on exposure to climatic vicisitudes, at sea. Thus, the Ceylon Rifles were attacked by intermittent fever, together with dysentery and diarrhœa, on their passage from Ceylon to Hong Kong in 1866.†

A gentleman of my acquaintance, who was attacked with intermittent, for the first time, 10 days after leaving Jamaica, was in perfect health all the time he was in that island, and continued so for 10 days after leaving it; but in the Atlantic, on exposure to cool winds, he was attacked by a severe quotidian fever.

In an expedition sent up the Zambesi river, in search of Dr. Livingstone, not a single case of sickness occurred while

* *Medical Sketches of Army in Egypt*, p. 6.
† *Army Med. Report*, 1866.

in the river or on shore, though the party suffered great fatigue and were exposed to intense heat for four months. But, on leaving the river, on board H.M.S. "Racoon," several members of the expedition were attacked with "rigors and slight threateniugs of a febrile paroxysm, but being promptly treated these were speedily checked." On the 7th day, however, one of the party, (a stoker,) was seized with a very severe attack of fever.* In this case, no febrile symptoms showed themselves, while the party remained in the sultry climate of the Zambesi; but they appeared immediately, when the men were exposed to the cool sea breeze, which to others was refreshing and salubrious.

On board H.M.S. Mutine, on the Pacific station, in 1866, eight cases of remittent fever occurred, of which the surgeon remarks: "Amongst these men there had been no exposure, in boats or otherwise, and no leave had been given for several months."†

On board H.M.S. Linnet, at Buenos Ayres, on the 23rd April, the ship having arrived six days before from Monte Video, the wardroom steward was attacked with intermittent fever; he had never previously suffered from the disease. On the 1st May an officer was attacked with the same complaint, who had two years before been ill of fever on the coast of Africa; the ship being still in the harbour of Buenos Ayres. Ten days after, the ship having in the mean time arrived at Monte Video, a leading stoker, who had suffered from fever seven years before, was attacked. Eleven weeks after this, and eight days after the ship had again arrived at Buenos Ayres, an able seaman, who had never previously been ill of fever, was attacked with intermittent, in the same way as the others, and had a recurrence of it five weeks later.

The surgeon observes: "The disease is very rare at Monte Video or Buenos Ayres; the men were not exposed to any malarious agent; they were not exhausted by hard work; and none of the crew had been out of the ship, at night, for a month before the first case occurred."†

* *Naval Medical Report.* 1867. † *Ibid.* 1866.

The surgeon of H.M.S. Antelope reports, that "from 1st October to 3rd December, five officers only, of all the European part of the ship's company, were on shore. Three of these officers went on shore several times, and once they slept on the open beach; one of the three was also exposed on a boat voyage along the coast. The latter, and another of the three who slept on the beach, were attacked with remittent fever of mild type. But no less than eight of the crew, *who had not been on shore,* were attacked with remittent fever, at sea, between 6th and 22nd November."*

These dates, it should be observed, were, respectively, 34 and 50 days after leaving the harbour of Sierra Leone.

In a report of three cases of remittent fever, on board H.M.S. Greyhound, on the African station, it is mentioned that the men had not been out of the ship. The surgeon considered the fever to have been caused, "by the change from the hot to the cold season; and the fall of temperature on going south."†

The surgeon of H.M.S. Wasp, on the East India station, reports: "On taking charge, I found 13 men on the sick list, 5 of whom were suffering from remittent fever contracted during the cruising; when they had had a good deal of boat work, and very wet weather."*

Thus, it appears that, although malarious fever is comparatively rare at sea, there is no foundation for the supposition, that it can only be contracted on shore; and, therefore, no occasion for astonishment at the marvellous periods of supposed incubation of the disease, which have been from time to time reported, such as that of 184 days, mentioned by Dr. Blaxall, R.N.‡

Winds have more influence, in the development of malaria, than is generally admitted. Most writers agree, that, blowing from the direction of a marsh, winds may carry malaria with them; but, if from any other quarter, they are supposed to drive it away. A current of air, of mild and equable temperature, blowing steadily throughout the hot season, as the south-

* *Naval Medical Report*, 1866. † *Ibid.* 1867.

‡ *Lancet*. Dec. 18th, 1869.

east trade wind does in the tropics, no doubt acts most beneficially. To this it is owing, as I have already mentioned, that the banks of the Amazon are so much more salubrious, than those of the other rivers of tropical America; and that, in the tropics, the windward side of most islands is more healthy than the leeward. In Guiana and the West Indies, and indeed throughout those latitudes, the most healthy ports are those exposed to the trade wind; and the healthiest season, that during which it blows.

If a wind be mild and equable, it tends not only to diminish heat by day; but also to lessen the degree of nightly chill.

Wells observes: "Bodies exposed on a clear night to the sky, must radiate as much heat to it during the prevalence of wind, as they would do if the air were altogether still. But in the former case, little or no cold will be observed upon them, above that of the atmosphere, as the frequent application of warm air must quickly return a heat equal, or nearly so, to that which they had lost by radiation."*

Unfortunately, winds are not always beneficial; for besides those blowing over marshes, which, parting with their heat and absorbing moisture, become cold, damp and unwholesome; the purest and freshest breezes may become the cause of malarious disease, in bodies predisposed to it from previous exposure to a hot climate, as in the case of the members of the Zambezi expedition, lately referred to.

The violent storms of the rainy season, in equatorial countries, bringing currents of air from cooler regions, are always, but especially on their first setting in, attended with a great development of "malaria"; and in the tropics, at sea as well as on shore, cases of fever are frequent in stormy weather.

The cold winds of the northeast monsoon, are considered especially injurious. Throughout Southern India, but especially on the east coast, the north-east wind is dreaded as much as it is in England. At Tanjore, "fevers, synochus and intermittent, are most frequent during the prevalence of the north-east monsoon, from exposure to cold winds."†

* *On Dew*, p. 72. Casella's Ed.

† *Madras Topographical Reports*, 1843.

"During the months of June, July, and August, while westerly winds prevail, fever, ephemeral and remittent, is common at Trichinopoly; but it has been observed invariably to become more so, on the setting in of the north-east monsoon; at which time exposure to the cold winds during the night, with insufficient clothing, conduces to the increase of fever."* In Mysore, whole villages are sometimes depopulated by fever, which the natives attribute to the cold dry easterly winds.† At Cannanòre, fever is said to owe its origin, not so much to any local causes, as to the effect of malaria conveyed from the western Ghats by a strong chilly east wind, which blows from an early hour in the morning till near midday, during the cold season.†

Pringle mentions having been assured, by the Physician General of the Austrian Army, that the malaria of the marshes of the Danube and Drave was intensified by the cold wind blowing at night from the Carpathian mountains, which were covered with snow.‡

Livingstone says: "On 19th February, both I, and several of our party, were seized with fever, and I could do nothing but toss about in my little tent, with the thermometer above 90.° We have had for the first time in my experience in Africa, a cold wind from the north."§

Dr. Dick, Deputy Inspector General of Hospitals, says, of Stanley, Hong Kong: "The post has been as a general rule very healthy, for at least nine months of the year, and it is chiefly at the change of the monsoon in September or October, that its sanitary state becomes unsatisfactory; and the reason of this seems to me obvious enough, for at this season of the year, the south-west changes into the north-west (east) monsoon, and the temperature of the wind changes from hot to cold, while the sun still retains almost its full power; the effect of which is, that the troops stationed there, are at the same time exposed to a burning sun and a cold wind; without any protection from either."‖ Dr. A.

* *Madras Topographical Reports*, 1843. † *Ibid.* 1844.
‡ *On the Diseases of the Army.* iii. 4. 188.
§ *Travels in Southern Africa*, 323.
‖ *Parliamentary Report, China*, 1866. p. 301.

Vans Best, of the Bengal Army, quoted by Dr. Chevers, also ascribes the prevalence of dysentery, diarrhœa, and fevers, at this station, to the north-east wind, and says: "The Chinese so well know the necessity of guarding against this wind, that whenever they can, they build their houses with a dead wall to the north."*

Cold night winds are especially dangerous in hot climates, and are a not uncommon cause of fevers in hilly districts; especially in places situated near ravines or mountain gorges, where descending currents of chilly air are frequently met with, and where "malaria" is often very intense.

One of the "chokees," or stations for palankeen bearers, on the Dalhousie road in the Himalayah, situated at an elevation of some 5000 feet above the sea, was so unhealthy, that of the 30 or 40 men always stationed there scarcely one escaped fever. I have frequently found more than a dozen men, at once, prostrated by intermittent, and most of the others suffering from the effects of the disease. Yet few situations could be found, so entirely free from all supposed sources of malaria.

The site was a narrow ridge of clay slate, connecting a large spur with the main range; in front and rear was a sheer descent of some 600 or 700 feet into deep, but open and rocky valleys, at the bottom of each of which ran a rapid stream over a steep and stony bed. The neighbouring mountains were precipitous; water had no chance of stagnating; trees, chiefly pine, were few and far between; and even grass was scanty. Two or three small villages near the "chokee" were healthy, but they were placed in sheltered spots; while, through the gorge, in which the unfortunate palankeen bearers were posted, an icy wind swept down, at night, from the snow-clad mountains beyond. This was the secret of the fever, and the station has since been removed, to a more sheltered site, with excellent effect.

The station of Madhopore, in the Punjab, is situated on the Ravee, nearly opposite the opening in the mountains

* *Health of European Soldiers in India.* Ind. Ann. Med. 1859. p. 670.

through which that river enters the plains. The position is 60 feet above the bed of the stream and is perfectly dry, open, and free from marsh. At night, earlier or later according to the season, a cool wind blows, from the Himalayah, down the narrow rocky valley of the Ravee. This breeze is fresh and pure, and can convey no marsh poison; it renders the nightly temperature of Madhopore, in the hot season, delightfully cool, compared with that of neighbouring stations, and contributes much to the general healthiness of the place; but any one sleeping exposed to its influence, with insufficient covering, is almost certain to be attacked by fever.

On the subject of cold night winds, Dr. Dunbar, of the Bengal Army, observes: "Directly in front of the camp was a ghat or pass, leading to the valley of Sumroo, whilst on each side of the ghat, a range of hills rose to the height of about 500 or 600 feet. The camp was pitched in paddy fields, which had only recently become dry, and in the rear was a thick and dirty jungle. The days were generally speaking close and hot, whilst during the night, cold and freezing gusts of wind swept with fury down the pass. I have experienced nothing in this country so cold, as were those nights we passed at Chitpele, which used to bring back to my recollection the mountain breezes of my native land."

"The effect of such sudden and remarkable variations of temperature were, as might have been expected, soon visible. Many cases of fever and dysentery were admitted into hospital daily, and at one time, out of a force of nearly 400 men, there were no fewer than 70 to 75 in hospital."*

Dr. A. Smith, in describing the diseases of Peru, says: "Near Payta, from 6 a.m. to 6 p.m. all is sunshine and heat; but, at sunset an icy wind blows down from the Cordillera, so that no bed clothes are sufficient, and causes a malaria so active, that it produces the most malignant remittent and intermittent fevers, which often prove fatal on first, second or third, accession; or sometimes continued fevers, lasting two or three weeks. The white inhabitants who survive these fevers, have enlarged spleen and liver."†

* *Indian Medical Journal*, 1836.

† *Transactions Epidemiological Society, London*, 1868.

Winds, then, are beneficial, in malarious countries, when they tend to maintain an equable temperature, and are injurious when they blow in sudden and chilling gusts; while exposure to cold night winds is especially dangerous, and this wholly irrespective of the neighbourhood of marshes or forests.

CHAPTER XIV.

SOME, HITHERTO, INCOMPREHENSIBLE PECULIARITIES OF MALARIA.

Malarious fevers on hills and table lands—In hottest and driest season—Dr. Heyne's observations—Fever diminishes on setting in of rains—Dr. Pearse, on Anamallay hills—Dr. McPherson's remarks—Cause of malaria in some cases temporary—These hills subject to much the same influences as plains—Higher parts of lofty ranges free from "Hill Fever"—Though it may prevail on their lower spurs—Dr. McPherson, on hills near Vizianagram—Prominent characteristic of "feverish" hills—During rainy seasons both temperature and fevers are mild—Night the dangerous time—Natives, who sleep in open air with little clothing very liable to fever—Report of Committee, on sickness at Scringapatam—Emanations from barren rocks supposed to cause fever—Humboldt, on fevers of Orinoco—Explanation—Angostura—Southern India—Hong Kong—Protective influence of fire and smoke recognised in all malarious regions—And from earliest ages—Instances in different countries—Explanation—Malaria less prevalent in towns than in country—Instances and explanation.

The effect of nightly chill is sometimes felt in places, and at times, when it would be little expected.

On some tablelands and amongst low ranges of hills, in Central and Southern India, as I have already mentioned, malarious fever, of a very severe type, prevails in the hottest and driest season.

Thus, "there are several parts of the Mysore country where fevers are endemic, as for example the 'droogs' or hill forts."*

This form of malarious disease prevails, at the same time, in dense jungles and amongst barren rocks.

Dr. Heyne, whose article on the subject has been quoted by several writers, observes: "This fever is particularly distinguished by the quick succession of its types, from intermittent to remittent, or to a continued typhus; which last, either carries off the patient, or passes again into an irregular intermittent. It has further the peculiarity, like the marsh fever, of causing enlargement of the liver and spleen. It exists as an endemic, among most ranges of mountains of

* *Madras Topographical Reports*, 1844.

this peninsula, confining itself to a very narrow circle (scarcely more than two miles) about each hill; it may be said to reign in these situations during the whole year, but it prevails most during the very hottest season, from March to June."*

"These hills," further observes Dr. Heyne, "are not more woody than other healthy places; some indeed, where the epidemic in 1808 and 1810, as well as the endemic, were most destructive, are quite naked of trees, as Dindigul, Madura, and the rocks west of Seringapatam. The vegetation is certainly at some seasons luxuriant, but this is only the case after the rains have set in, when the fever has disappeared."

"Nothing but bare rocks and stones and brown earth, can be seen on the surface of these hills, or in the jungles; neither can there be a want of ventilation, for where the temperature differs 20° to 30° in the twenty-four hours, as it *often does here*, and where the hills are mostly in single lines and nearly naked, there must be, and there is, a strong draught and ventilation in the course of the day."

"The hottest season, when the rocks exposed to the meridian rays of the sun are heated to 220°, is the epoch when the fever rages most."

"It has been observed, that the night air of such places is particularly to be dreaded."

"The first heavy rain, in June, banishes, in some degree, this fever, for the rest of the year, and certain places, where it raged a week before, are resorted to as healthy and delightful."

"It is known that this fever terminates about the same period after the first rains, at Seringapatam, in the Wynaad, and other places."*

Here we have an instance of malarious fevers of a very severe form, arising on and near rocky hills, (some covered with jungle, and others perfectly barren,) at the hottest and driest season of the year; when, in almost all cases, vegetation is

* *Madras Quarterly Journal*, Vol. iii. April, 1841.

so parched and burnt up, that nothing but the bare earth or rock is to be seen. But no sooner does the rain fall, the earth become saturated with moisture, and vegetable decay become possible, than the fevers, in some cases, almost entirely disappear; while in others, they take the milder intermittent form.

In a report on the Anamallay hills, which are situated in the part of India to which Dr. Heyne refers, Inspector General of Hospitals Dr. Pearse, observes: "The working season of the forest department in these hills extends from July to January (the rainy and cold seasons); during the remaining six dry months of the year, the forest is altogether abandoned; the fatal character of the fever, which then appears in all its intensity, rendering this course necessary."

"Fevers of a milder type prevail at all seasons."*

Indian hill fevers may well be a puzzle to those who believe malaria to be an organic poison. But when these diseases are considered as the result of climatic causes only, the phenomena connected with them are readily explained.

This so-called "hill fever" is, it must be observed, not confined to the sides or summit of hills, nor even to the two miles radius assigned to it by Dr. Heyne. The same disease occurs in the neighbouring plains, in the Wynaad, and in most other jungle tracts of Southern India; as well as in districts further north. It is not confined to dry places, for the same form of fever is well known in the Terai and in lower Bengal. It is to be observed, however, that, whether in dry or in moist localities, this severe type of malarious disease is most prevalent during the greatest heat.

In some localities, where these fevers are general during the hot season, the laterite formation is common; and stiff retentive soils, with impervious rocky subsoil are frequently met with. Such ground, though it becomes parched and dry on the surface, generally retains a certain amount of moisture in its recesses, throughout the hot season. And this is especially the case at the foot of hills, in ravines,

* *Report of Royal Commission on Sanitary State of Army in India*, ii. 615.

or on the lower spurs of lofty ranges; the moisture collecting in these situations, where also this form of malarious disease is most frequently contracted. Hot weather fevers, however, are not confined to such places, for they occur, as already observed, in plains; and also, as mentioned by Dr. Heyne, on bare and rocky hills, where there is little or no soil, and therefore no jungle. Dr. McPherson says, of the hills near Russelcondah: "Immediately beyond the station, high hills ascend and extend for miles, but none of them possess the elevation or other requisites, which would attract European colonists. They are bare, dry, and very unhealthy."*

In some instances, the cause of these fevers appears to be temporary, induced, no doubt, by irregularity of the seasons. Dr. McPherson, writing in 1859, mentions that some 24 years earlier, a deadly fever was supposed to be the certain result of a visit to the hill of Ramandroog.† Yet this height has been of late years a favourite sanitarium; in 1867, however, it was visited by an epidemic of 'intermittent.'‡

"Nundidroog, once a place of resort, was abandoned after some years as unhealthy, and lately is supposed to have again become healthy."§

Dindigul was abandoned in 1810, owing to the deadly nature of the fever which prevailed there, and was re-occupied in 1813.‖

Of Yercand, in the Sheveroy hills, at an elevation of 4500 feet, Dr. McPherson observes: "Here the surface is broken, rocky, and jungly, and it has been subject to occasional severe visitations of fever, either from inattention to sanitary requirements or from the failure of the regular monsoon."¶

The effect of a failure of the monsoon, or in other words, of the absence of rain, is, as may be supposed, to add greatly to the severity and duration of the hot season.

* *Report of Royal Commission on Sanitary state of Army in India*, ii. 636.
† *Ibid.* ii. 646.
‡ *Army Medical Report*, 1867.
§ *Madras Topographical Reports*, 1844.
‖ *Ibid.* 1843.
¶ *Report of Royal Commission on Army in India*, ii. 641.

The severe type of fever referred to, prevails upon hills of no great elevation, or on the lower spurs of more lofty ranges. As these hills do not attain the cooler strata of the atmosphere, they are subject, more or less, to the same heating influences as the neighbouring plains, intensified, in some cases, by their rocky formation and by their comparatively isolated position; owing to which, they become strongly heated by day and readily chilled by night. The variations of temperature may, therefore, in the hot season, be even greater on these low hills, than in the neighbouring plains; while the dews are often very heavy. The summits of those hill ranges, whose altitude is sufficient to reach the cooler regions of the atmosphere, are free from the so-called "hill fevers," even though these may prevail on their lower slopes; and though the higher parts of the range may be as thickly wooded, and of much the same geological formation as the less elevated spurs. Dr. McPherson says, of the hills near Vizianagrum: "On the more elevated of these, a site has been fixed for a sanitarium. But a deadly fever is the almost certain result of a night passed on the lower elevations."*

The most prominent characteristics of the low hills and jungles referred to, at the season in which hot-weather fevers prevail, are intense heat by day, and a damp and chilly atmosphere at night, almost invariably attended with a copious formation of dew.

During the rainy season, on the other hand, the setting in of which drives away these fevers, the earth and the atmosphere are saturated with moisture, the temperature, as Dr. Heyne tells us, falls to 74°, evaporation and nightly radiation are reduced to a minimum; and the climate is mild and equable.

These situations remain comparatively healthy throughout the rainy and cold seasons, and until the intense heat again sets in.

In these ranges, whether wooded or barren, as in marshes and in swampy jungles, night is the time to be dreaded; and,

* *Report of Royal Commission on Sanitary State of the Army in India*, ii. 636.

as Dr. Heyne observes, the natives, who sleep in the open air with little or no covering, are more subject to tho fever than Europeans, who are of course seldom unprovided with tents and bedding.

There can be littlo doubt that the cause of these "hill," or "jungle fevers," as well as of other forms of malarious disease in the tropics, is exposure to chill after a continuance of very great heat.

In confirmation of these views, I may quote the following remarks, from the report of a special medical committee, appointed by the government to enquire into the cause of the sickness in the garrison at Seringapatam, one of the places mentioned by Dr. Heyne, as especially noted for the mortality caused there, by the "hill fever."

"Seringapatam, being under the influence of both north-east and south-west monsoons, rainy weather prevails from the beginning of May, till the beginning of December. The latter part of that month, January, February, March, and April, are dry and sultry. From the middle of December till February, cold bleak N.E. winds prevail; between that period and the commencement of the S.W. monsoon is the hottest weather."

"Heavy dews and damp atmosphere prevail, more or less, throughout the whole year, but more particularly during the months of January, February, March, and April; the variation in the temperature, between day and night, is also greatest at this season."*

"From the commencement of the hot weather in the middle of February, to the beginning of May, the difference of temperature, between the day and night, is extreme, and *this is the season* when the bilious remittent fever, the most fatal disease at this station, rages with the greatest violence."*

I have already alluded to the belief, common amongst the natives of hot climates, both in the old and in the new world, that bare, dry rocks produce malarious fevers.

Humboldt, who considered this belief superstitious, ob-

* *Madras Quarterly Journal*, Oct., 1841.

serves: "The fevers which prevail during a great part of the year in the villages of Atures and Maypures, around the two great cataracts of the Orinoco, render these spots highly dangerous to European travellers. They are caused by violent heats, in combination with excessive humidity of the air, bad nutriment, and, if we may believe the natives, the pestilent exhalations rising from the bare rocks of the "raudales." At Carichana the village is intended to be destroyed, and its place changed, merely to remove it from the black rocks, or from a site where for a space of more than ten thousand square toises, banks of bare granite form the surface." Some idea may be formed of the nature of the exhalations from these rocks from Humboldt's observation, that "when walking between the hours of one and three in the afternoon at Carichana, Atures, or Maypures, amongst blocks of stone, destitute of vegetable mould, and piled up to great heights, one feels a sense of suffocation, as if standing before the opening of a furnace."*

Humboldt found the temperature of these rocks to be, during the day, 48° C. (118°·4 F.), and in the night, 36° C. (96° ·8 F.)* The reading of the thermometer at daybreak is not given; but, as the loss of heat, at the time of observation, already amounted to 21°·6 F., increasing at the same ratio, it must, by the morning, have been very great.

Here, is a clue to the mystery of the poisonous exhalations from the "laxas negras." The heat by day is very great, and so is the nightly fall of temperature, while the effect of the latter, upon animal bodies, is intensified by the condensation of the enormous quantity of moisture in the atmosphere, which is alluded to by Humboldt, as a probable cause of the fever.

The exhalations from the black-crusted granite are considered much more deadly, than those from that, of a brown or reddish white colour, in the same neighbourhood. This confirms what has just been said, as Humboldt remarks: "I observed pretty constantly in putting the bulb of the ther-

* *Narrative of Travel*, xx. 242, 247.

mometer in contact with the ledges of bare rock, that the "laxas negras" are hotter during the day, than the reddish white granites at a distance from the river; but the latter cool, during the night, less rapidly than the former." This writer continues: "It may be easily conceived, that the emission and loss of caloric is more rapid in masses with black crusts, than in those which abound in laminæ of silvery mica.*

In the City of Angostura, situated on the Orinoco, at the foot of a hill of hornblende schist, bare of vegetation, Humboldt found the same dread of exhalations from the rocks, when acted upon by intense heat;† and here, the cause of the evil was undoubtedly the same as at Cariehana.

The malignant influence of the rocky hills of Southern India during the hot season, attributed by Dr. Heyne to magnetic causes, and the emanations supposed to arise from the granite of Hong Kong, and of other places, in the tropics, are, without doubt, of the same nature as those above alluded to; and the noxious properties of the rocks are owing to nothing more, than the intense heat accumulated by day, (reaching, as Dr. Heyne tells us, to 220° F.,) succeeded by a chill, and generally damp atmosphere at night.

In all climates the evil influence existing in malarious places, from whatever source this is supposed to arise, is known to be counteracted by fire; and the protection of this powerful agent has been invoked, in such situations, from the earliest ages. As Lancisi observes,‡ the myth of the destruction of the Lernean Hydra by Hercules, which could only be accomplished by the aid of fire, points to this.

Hippocrates is said, by means of fire and smoke, to have arrested the pestilence at Athens; and Acron is said to have done the same at Agrigentum, by turning a cold and damp atmosphere, into a warm and dry one.§

Pliny alludes to the use of fire for the same purpose.

* *Narrative of Travel.* xx. 247.
† *Ibid.* xxv. 519.
‡ *De Noxiis Palud. Effluviis,* Lib. i. v. 79.
§ *Paulus Ægineta.* i. 273. Sydenham Ed.

At the present day, the protection from malaria, which is afforded by fire and smoke, is recognised both by the civilized man and the savage.

In Central Africa, no negro thinks of spending the night without a fire. Livingstone refers to the beneficial influence of this powerful antidote to malaria. Lind mentions, that the negroes of the Guinea coast, on the setting in of the rainy and sickly season, retire into well-thatched huts, where they keep fires lighted.*

In Venezuela, Humboldt found, that every Indian had a fire close to his hammock.†

In India, the natives know well the value of fires at night, as a protection against fevers. The Goojur herdsmen, huddled together round their fires, brave the deadly "awal" of the Terai. The Jeeva, wrapped in his wadded coat and protected by a fire, watches his nets, night after night, unharmed amidst the malaria of the swamp.

In Madagascar, a fire is kept smouldering at night in every house, as the natives believe, that the poison then rises from the ground, and can only by this means be destroyed.‡

Davy, says: "In Ceylon, the natives carefully avoid night air and, in the interior, generally have a fire in their sleeping rooms." He also mentions, that at the temple of Kuttragaum, in one of the most unhealthy districts of the island, where a great number of the pilgrims are swept off annually by disease, the officiating priest had lived for a number of years with impunity; and that the only precaution he took, was to sleep in an inner room, with a fire burning in the middle of it.§

Monfalcon tells us, that when the French, before Mantua, were obliged to bivouac amidst the swamps, Napoleon maintained the health of his troops by keeping up large fires.‖

* *On the Preservation of Health of Europeans*, &c. ii. 51.
† *Narrative of Travel*, ix. 309.
‡ Davy, *Topography of Ionian Islands*, &c. 256.
§ *Ibid.* 252.
‖ *Traité des Marais*, 201.

It is often recommended that in case of epidemic disease, in a camp, large fires should bo lighted to windward; but beyond a vague notion, that the poison has some difficulty in getting past it, very few people have any idea as to how either flame or smoke is beneficial.

Under any of the usual theories on the subject of malaria, the influence of fire and smoke, in counteracting its effects, is not to be easily explained; but, when taken in connection with the views expressed in this work, their mode of action becomes at once apparent.

The most evident effect of large fires is to heat the current of air passing over them, depriving it of part of its moisture; while the smoke, forming a cloud overhead, effectually checks the radiation of heat. In short, the night air is kept warm and comparatively dry, as in the case of Agrigentum, just referred to.

In producing these effects, smoke plays a very important part, as it contributes greatly to diminish the nightly cold.

We are told, that "in the clear blue sky of the valley of Chamouni, if the crops should not have ripened towards the end of the season, the peasants make fires of green wood, on the sides of the enclosing mountains, the smoke of which, uniting in the middle, forms a kind of cloudy canopy; which not only prevents the escape of radiant heat, but increases its intensity, and prevents the formation of frost."* A similar use is made of smoke in other parts of the world.

Fire, therefore, by maintaining warmth at night, is the antidote, at once, to malaria and to chill.

Malaria is often said to be less prevalent in towns than in the country.

Pringle observed, that the troops in Holland suffered much less from fevers, when stationed in towns, than when quartered in the country, though the positions were only a distance of a mile apart.†

* Wells, *On Dew.* Casella's Ed. p. 104.

† *On Diseases of the Army*, Part i. viii. 63.

La Roche says, that the city of Louisville on the Missisipi, was at first so unhealthy from the effects of malaria, that it was called the "grave yard of the west." But, as drainage was improved and building extended, it became one of the healthiest cities on the river. Still, however, it is always observed, that the nearer to the centre of the city, the less is the danger of malarious disease; and that streets, which were unhealthy, become healthy as buildings extend beyond them.*

A very similar change has taken place in London, since Sydenham's time.

I have been assured, by a gentleman who spent many years in Spain, that, in the most malarious districts of that country, the large towns are comparatively free from intermittent fever.

Dr. Dempster mentions, that, in the city of Delhi, and especially in the most dense and crowded quarters, he found comparatively few indications of the malarious disease, which, prevailing to a considerable extent in the outskirts, was present in its highest intensity in the neighbouring country.†

Macculloch suggests, that the immunity of towns, from this cause of disease, is owing to the decomposition of the malaria by the smoke ;‡ this, however, is scarcely reconcileable with the supposition, that, owing to its great density, the poison must always remain near the surface of the ground.

There is one way, nevertheless, in which, as I have already shown, smoke may destroy malaria; and that is by checking the nocturnal radiation of heat. It is well known that the nightly temperature of towns is higher than that of the open country, partly for the reason just mentioned, and partly from the influence of numbers of fires, and of the heat retained by buildings. The absence of damp, owing to drainage, and to the small surface exposed for the absorption of moisture, also contributes to render the night air of towns com-

* *On Pneumonia, &c.*, iii. 255.

† *Report of Royal Commission on Army in India.* i. 474.

‡ *On Malaria*, p. 293.

paratively warm and dry. Dew is much less copious in towns than in the country.

Davy observes, that in August and September 1833, the greatest diurnal variation of temperature in the town of Valetta was 4° F., while in the country it was 20° F.; and in the course of two months, the greatest variation in the town was 13° F., while in the country it was no less than 39°.* If, then, we look upon the chill and damp of the night air as malaria, it becomes easy to understand how it is held in check by the dryness and warmth of the town, with its smoky canopy, and numberless fires.

* *Topography of Ionian Isles and Malta*, 264.

CHAPTER XV.

INFLUENCE OF HEAT IN CONNECTION WITH MALARIA.

Effects produced by continued exposure to a very high temperature—Humboldt's observations—Remarks of Sir J. R. Martin, and Dr. Morehead—Malarious fevers always most prevalent after great heat—Pringle's and Fergusson's observations—Effects of insufficient protection from calorific influences—Pringle's remarks—Author's experience—McKinnon's observation—Cause of unhealthiness of casemated barracks and forts in India—Effects of exposure to sun—Remarks of Drs. Dick and Murchison—Chill a cause of malarious fevers during great heat and drought—Explanation—Type of malarious fevers aggravated in hot season—Ferguson's remarks—Fevers more severe after unusually protracted heat, and most malignant in hottest climates—Some forms of fever caused by heat—Dr. B. W. Richardson's remarks—This class of diseases not considered malarious—Yet most intimately connected with remittent and intermittent fevers—Disorders considered to be result of climatic influences, scarcely distinguishable from others, supposed to be caused by a specific poison—Dr. McKinnon's remark—Connection between ardent and malarious fevers explained.

It is known, that, after long exposure to great heat, the system becomes more sensitive to, and less capable of resisting, the effects of cold; and that after a residence in the tropics, or even after a long period of hot weather in cooler regions, the body becomes sensitive to a fall of temperature, which, in a milder climate, or a cooler season, would scarcely be perceived. Humboldt, in noticing this fact, observes: "Though we had yet scarcely been two months in the torrid zone, we had already become so sensible to the smallest variation of temperature, that the cold prevented us from sleeping; while to our surprise, we saw that the centigrade thermometer was as high as 21°·8 (71° F.). This fact is familiar to those who have lived long in the Indies, and is worthy of the attention of physiologists."*

Humboldt, again and again, alludes to the effects of continued heat, and observes, that "it is generally the duration of a high temperature, and not the excess of heat, or its absolute quantity, which occasions the sufferings of the inhabitants of the torrid zone."†

* *Narrative of Travel*, v. 177.
† *Ibid.* xi. 378.

This writer mentions, that at Cumana, where the average temperature is 27°·7 C. (82° F.), during heavy showers, people in the streets are heard exclaiming, "what an icy cold, I shiver as if on the top of the mountains," though the centigrade thermometer exposed to the rain sinks only to 21°·5 (71° F.)."*

In India, and in all hot climates, a similar sensation of cold is experienced on the setting in of heavy rain, although the thermometer may only fall a few degrees; and this is particularly the case after long drought.

This extreme sensitiveness to the slightest sudden abstraction of heat, owing to the heat-producing power being weakened by long-continued exposure to a high temperature, has not received the attention which it deserves, in connection with the study of the causes of "malaria;" although it has been alluded to by several writers.

Sir J. R. Martin observes, of the cold season in Bengal: "It is then we become aware of the effect of long-continued exposure to a high range of temperature, through our extreme predisposition to be injuriously affected by cold."†

Dr. Morehead, too, remarks: "In judging of the facility with which the temperature of the surface of the body becomes reduced in India, we must bear in mind the diminished power of generating animal heat, characteristic of warm climates and asthenic states; and that, consequently, in these circumstances, the surface of the body may become lowered in temperature by an amount of external cold, inadequate to produce this effect in colder climates, or stronger constitutions."‡

In some cold climates, and even in elevated situations in warmer latitudes, malaria is very rare, except after hot summers. Everywhere it is most intense after unusual heat, but this is especially the case when the change to comparative cold is sudden.

"This putrid remitting fever," says Pringle, "attended

* *Narrative of Travel*, v. 178.

† *Influence of Tropical Climates*, &c, p. 39.

‡ *On Disease in India*, i. 7.

every campaign, but was most fatal after the hot summers of the years 1743 and 1747. In 1744 and 1745 the seasons being temperate, fewer were seized and the cases were milder."*

Again, the same writer says: "Intermittent and remittent fevers are worst after hot summers in the Netherlands."

Fergusson observes, that in 1794, when intermittent and remittent fevers were epidemic, in the army in Holland, "the summer had been hot and dry."

"In 1799, the army, in the worst part of the same country, had no fever, the summer was wet and cold." Again, in 1810, the year of the Walcheren expedition, "the summer had been hot and dry."†

A very great prevalence of malarious fevers, after a period of unusual heat, is frequently noticed in every part of the world. In 1865, the heat had been very great at the Mauritius, for some time before the epidemic of malarious fever appeared. At Hong Kong, in the same year, the heat was unusually great.‡ The hot season, in Northern India, last year, was very severe. In each of these cases, the extraordinary heat was followed by a great prevalence of malarious disease. Great as the heat always is, on the coast of Africa, a hotter season than usual is followed by an increased prevalence of fevers. On board H. M. S. Pioneer, at the mouth of the Congo river, on the setting in of the "rains" after an unusually hot and dry season, every white man, with one exception, was seized with remittent fever; and the sickness was equally severe amongst the merchant shipping and on shore.§

The predisposing effect of heat is generally, as might be expected, more intense in proportion to the degree of exposure to it; so that men, much exposed to the direct rays of the sun, or insufficiently sheltered from solar influ-

* *On Diseases of the Army*, iii. 4. 172.

† *On the Nature and History of the Marsh Poison.* Trans. Royal Society of Edin. Vol. ix.

‡ *Parliamentary Report, China*, 1866. p. 415.

§ *Naval Medical Report*, 1867.

ence, are very subject to the attacks of malarious disease. This was strikingly shown in China, in 1865, and is often seen in India; where the difference between a cool house and a hot one, or a large, thick tent, and a small, thin one, is fully appreciated. The effects of insufficient protection from solar influence did not escape Pringle, who says: "Soldiers in camp suffer a great deal from heat, by being constantly exposed to the sun, either without any shade at all, or only sheltered by a thin tent; where the air being so much confined, the heat is often more insupportable than without, in the sun. This circumstance, joined to the damps of a camp, seems to be the cause that the summer and autumnal diseases of an army, even in a northern latitude, resemble so much the epidemics of southern countries; especially of those with moist air."*

I have frequently known case after case of fever occur, in small, and badly arranged houses, in which the heat was very great; when more roomy and cooler dwellings, in the same neighbourhood and on similar sites, were free from the disease. At Madhopore, the people living in one or two small houses, which afforded very insufficient protection from the heat, were frequently attacked by fever, sometimes of a very severe type; while those inhabiting larger and cooler buildings, some of them within a distance of one or two hundred yards, were perfectly free from it; the sites in each case, being precisely similar. Dr. McKinnon, with reference to these fevers, truly observes: "Good house accommodation is a great safeguard."†

The intense heat and very great unhealthiness of case-mated barracks, in tropical climates, are proverbial. In most forts in India, even where the barracks are not case-

* *On Diseases of the Army*, ii. 2. 79.

† *On Climatic Fevers.* Ind. Ann. Med. v. 153.

In connection with this subject, I may observe that, in a tropical climate, the roof of a house has nearly as great an influence as the floor, upon the health of the inmates; although this seems to be sometimes overlooked. It is most probable, that the intense heat, and consequent unhealthiness, of some of the new two-storied barracks in India, is, in great measure, owing to their slate roofs, which are quite unfit for such a climate; slate being a most powerful absorbent of heat.

mated, the proportion of fever cases is very large; and the heat, in almost every case, from the presence of large masses of rock or masonry, is very great.

In the fort of Jhansi, built upon a barren rocky hill, the heat was intense; and the garrison suffered much more severely from intermittent and remittent, as well as from ardent fevers, than did the troops in the neighbouring cantonment.

In the fort of Lahore, in 1867, there were 107 cases of paroxysmal fever in an average strength of 62 men.*

Staff Surgeon Home mentions, that at Peshawur, in 1865, while the officers managed to cool down their bungalows to 90°, the men's barracks had a temperature of 110°. No unusual sickness amongst the officers is mentioned; but, amongst the soldiers, the proportion of fever cases was 955 in 1000 men.†

Troops exposed in tents, in a hot climate, often suffer very severely from fevers; especially on the change from the hot to a cooler season.

If the predisposition to malarious disease may be diminished, by good shelter from calorific influences, it may be aggravated, as might be supposed, by exposure to the primary source of heat. It has often been noticed, that insufficient shelter from the sun's rays predisposes to malarious fevers; so much so, that, as mentioned by Lind, Blane, and others, it has been considered a frequent cause of these diseases.

Deputy Inspector General Dr. Dick says, with reference to the fever at Hong Kong; "There can be no question, solar influence is of itself, an effective predisposing cause of fever and other malarious diseases."‡

What is "solar influence," but, another name for heat?

Dr. Murchison observes, that at Prome, most of the men who were necessarily exposed to the sun, suffered from cephalalgia, and other symptoms of cerebral congestion, and many, a few hours after, were attacked by fever.§

* *Army Medical Report*, 1867.
† *Army Medical Report*, 1865.
‡ *Parliamentary Report*. China, 1866. 219.
§ *On the Climate of Burmah*, 25.

The impression, that malarious fevers may be produced by exposure to the sun's rays, prevails in all hot climates. Humboldt mentions, that, at La Guayra, one of his neighbours, seeing him exposed to the sun, insisted upon his swallowing a dose of physic on the spot, to keep off fever.*

It may appear paradoxical to speak of chill as a cause of disease occurring during the most intense heat, when the fiery "hot wind" is blowing night and day, little difference is to be felt between the daily and nightly temperature, and no trace of moisture is perceptible, in atmosphere or soil. Yet, such is the predisposing effect of a continued high temperature; so sensitive does the system become to the slightest abstraction of heat; and, in such a dry state of the atmosphere, so powerful is the refrigerating effect of evaporation from the perspiring surface of the body, especially if aided by currents of air; that a sensation of chill may sometimes be felt, even during exposure to the hot wind. A powerful current of dry and heated air may chill the body, by acting upon its perspiring surface, and the moistened clothing, as effectually as it reduces the temperature of a room, by evaporation from the wetted grass of a tattie;† and in the same way.

At Jhansi in June 1860, a young officer, of the Battery of Artillery to which I belonged, was exposed for some time to the sun at mid-day; he then in a profuse perspiration came into the house, through which a hot wind was blowing, as all the wood work had been burnt by the rebels, and the tatties, which served for doors and windows, were almost dry: in a few minutes he complained of feeling chilly, and, in a few more, he was in the cold stage of a sharp attack of intermittent.

This officer had never previously suffered from fever, when he went out a short time before he was in perfect health, and he had not, whilst away, been into any malarious locality; in

* *Narrative of Travel*, xi. 386.

† A bamboo frame, thatched with khus khus or grass, which, being kept wet, cools the air passing through it.

Tatties are placed in the doorways, on the windward side of a house, in the hot season; and the stronger and hotter and, therefore, drier the wind, the greater is their refrigerative power.

fact, at that season, the whole country round was parched and perfectly dry.

A year after this, I suffered from a severe attack of the same complaint, which came on, during a morning call, from sitting under a punkah in a cool room after riding through the sun and hot wind, at mid-day, in the month of April. I went into the house perfectly well, but had not sat there ten minutes before I felt the sensation of cold water running down my back; and, in a few minutes more, my friends had to put me to bed, shivering with ague.

Sitting, or sleeping, near a tattie is a frequent cause of fever, as well as of dysentery and other diseases. And who, that has passed a hot season in the plains of India, has not a vivid recollection of the sensations experienced when, in the close, stifling atmosphere of the night, the punkah was stopped, even for a moment;—the suffocating heat;—the bath of perspiration:—and then, the chilly feeling, when the air again set in motion by the punkah, caused a rapid evaporation, from the wet clothing and perspiring skin. Chill, from such a cause as this, is a fruitful source of fever in the hot season.

The influence of heat, in connection with malarious disease, is further shown, by the aggravated form assumed by fevers in the presence of a very high temperature, whether combined with drought, or with moisture; and by the milder form they acquire, as the climate becomes cooler.

It is well known, that in hot countries, malaria is more powerful than in cold ones; in fact, that as the intensity of the heat, so, as a rule, is the intensity of the malaria.

"Degrees of disease," says Fergusson, "might be almost measured by degrees of solar heat, from the agues of Lincolnshire to the malignant remittent of the West Indies."*

It has been observed, that not only is there a tendency in malarious fevers to assume the remittent and continued type

* *On the Nature and History of the Marsh Poison.* Trans. Royal Society, Edin. Vol. ix.

in hot climates, and the intermittent in cooler ones, but, that this relation extends also to the seasons; that fevers of the remittent and quasi continued forms prevail during the hottest months; the type changing into intermittent with a fall of temperature, though sickness may then become more general. Even in temperate climates, the type of fever is most severe towards the end of a hot summer, becoming milder as the season grows cooler; although, from the greater degree of nightly chill, the number of those attacked may then be increased.

Pringle says: "But it was observable, that even in the worst parts of that country, as soon as the weather cooled on the advance of autumn, the fever began to assume a milder form."*

"In Mysore, in the hot season, bilious remittents and fevers of a typhoid character frequently occur, as also dysentery &c. It is however on the setting in of the monsoon, that fevers are most prevalent, the intermittent being then the prevailing type."†

"At the termination of the monsoon and setting in of the cold season, fevers are very prevalent, but are of milder type."†

Dr. Eatwell observed, in China, that at the commencement of the hot season the type of fever changed from intermittent to remittent; and again, that the remittent faded into the intermittent form, on the setting in of the cool season.‡

"At Peshawur, which is beyond the range of the monsoons or tropical rains," says Dr. MeKinnon, "continued and remittent fevers prevail during the hot months, when the temperature is very high; while intermittents are most common in and after September, the weather having become cooler, though there may have been no rain."§

Davy observes that "in the islands and on the shores of

* *On Diseases of the Army*, iii. 4. 180.

† *Madras Topographical Reports*, 1844.

‡ *Report of Roy. Commission on Sanitary State of Army in India.* i. 481.

§ *Indian Ann. Med.* 1856, No. v. 150.

the Mediterranean, and also in Ceylon, the severest form of fever, that of the remittent kind, is most rife in the hottest weather."*

In Algiers, it is in the months of July, August and September, when heat is intense, rain and clouds are rare, and the earth presents the appearance of a desert, that the simple, quickly-cured intermittent fevers of spring, assume a form more or less grave, take on remittent, pseudo continued, and continued types, and invest themselves with typhoid symptoms.†

At Aden, where the heat is intense, but the soil contains little or no moisture, except immediately after rain, and vegetation cannot exist, the remittent and continued are the most prevalent forms of fever, amongst the white inhabitants; while the black races, upon whom heat has not the same effect in depressing the vital powers, suffer chiefly from intermittents.

In countries where the heat is very great, and there is little or no cool season, fevers of the remittent or continued type occur at all times.

On the coast of equatorial Africa the fevers, which so constantly prevail amongst the whites, are of the remittent and continued form; while, as Livingstone observes, from Lat. 8° south, "they almost invariably take the intermittent or least fatal type;" and in Lat. 20° south, even this form becomes rare.‡ Thus, the gravity of the disease regularly diminishes with the temperature.

In the West Indies, and on the neighbouring coast of South America, bilious remittents prevail at all seasons.

In fact, whenever fevers prevail during great heat, they evince the same tendency to assume the remittent or quasi continued form, whether the country be dry and barren, or marshy and covered with rank vegetation; which shews plainly the influence of heat, in causing the greater intensity of the disease.

* *Topography of Ionian Islands, &c.*, 247, 281.
† Haspel, *Maladies de l'Algerie*, ii. 165, 182.
‡ *Travels in Southern Africa*, 505.

Some forms of fever are caused by continued exposure to great heat alone. Insolation and the ardent fever of hot climates are ascribed, by most authorities, to this cause.*

As these diseases are not generally attributed to "malaria," to discuss them, at any length, is not within the scope of this work; my object, in alluding to them, is to notice that some fevers, very closely connected with those known as "malarious," arise from climatic causes.

Dr. B. W. Richardson observes: "An animal which cannot cool down rapidly enough, to meet even a moderate increase of external temperature, will show increment of heat that shall be fatal, in an air in which another animal may live unaffected. An animal subjected to active oxidation, while the conditions for equalisation of heat are imperfect will suffer from increment of heat and may die."†

These observations have a very important bearing upon the subject under consideration.

While in a good state of health, and exposed to no other untoward influence, a man may maintain a state of equilibrium of temperature, even, when exposed to intense external heat. But, if from debility, exposure to fatigue, or any other depressing or untoward influence, the vital functions, especially those of circulation, respiration, and cutaneous evaporation, are embarrassed, the equilibrium may be destroyed; and the man be placed, at once, in the position of the animal referred to by Dr. Richardson; fever being the result.

It is found consequently, that those who are affected by insolation, heat apoplexy, or ardent fever, are generally the weakly; (frequently patients in hospital, or convalescents;) those suffering from fatigue; or those engaged in active physical exertion. Men, also, are frequently attacked, who during intense heat are parched with thirst.

These diseases, and the so-called "malarious fevers," arise

* Martin, *Influence of Tropical Climates*, &c. 204.—Morehead, *On Disease in India*, ix. 165.—Day, *On Tropical Non-malarious Fevers*. Indian Ann. Med. No. xi. 71.—Longmore, *On Heat Apoplexy*. Indian Ann. Med. No. xii. 402.

† *Medical Times and Gazette*. Jan. 29th, 1870.

under different circumstances. The former occur only during periods of great and continuous heat; and, except in rare instances when the temperature remains very high during the night, the attacks take place in the day time. Yet, remittent and intermittent fevers are frequently found to supervene upon attacks of ardent fever, or of insolation. So often is this the case, that some writers have assigned a malarious origin to the latter diseases.*

Dr. Henderson, quoted by Sir J. R. Martin, says: "Where the line was to be drawn between apoplexy and remittent fever, is here difficult to say."†

Insolation and ardent fever are, however, admitted to arise from *climatic causes only*,‡ by those who insist, that remittents and intermittents are the results of an organic poison.

Further, some of the forms of fever, considered by writers to arise from climatic causes, are distinguished with so much difficulty from those, which are said to be the result of a specific poison, that so careful an observer as Dr. Morehead says, of the diagnosis between common continued fever, which he considers non-malarious, and malarious remittent: "This diagnosis is materially assisted, by bearing in mind whether the season is one generally free from malaria or not, whether the temperature is very high, and whether the sufferers have been previously exposed to malarious influence or not. The character of the febrile disturbance likewise assists us;—as whether there is much cerebral or gastric complication, and whether the remission is distinct."§

To enable us to distinguish, therefore, between two classes of disease, one arising from purely climatic influences, and the other supposed to arise from an organic poison, less dependance is to be placed upon the symptoms, than upon the

* Hill, *On Heat Apoplexy*. Indian Ann. Med., No. v. 207, 210.

† *Influence of Tropical Climates*, &c. 204.

‡ "But between the pathology of ardent and remittent fever, there is believed to be this great difference. In the former there is no materies in the blood, as in the latter, exercising a sedative influence on vital actions, and requiring time for its elimination."—Morehead, *On Disease in India*, viii. 166.

§ *On Disease in India*, v. 57.

presumed existence, or non-existence, of a hypothetical "malaria," at that particular season. And although the supposed causes are so dissimilar, so little difference is there in the diseases which result, that the character of the febrile disturbance only "assists us" in the diagnosis.

Dr. Mackinnon well observes: "In fact we may be very sure, that under what head a particular case of fever is entered, often depends upon arbitrary and preconceived opinion."*

It is impossible, under these circumstances, to explain the relationship between the two classes of disease referred to; but, if we look upon each of these forms of fever as resulting from climatic causes, it becomes easy to understand the nature of the intimate connection, which undoubtedly exists between them.

I have shown, that a specific poison is no more necessary in the case of intermittent or remittent, than in that of ardent fever; and further, that the exposure to intense heat, which gives rise to the sun fever, is also the most powerful predisposing cause of the remittent or intermittent, which so often follows it. In this, consists the relationship between these two classes of disease.

* *On Climatic Fevers.* Indian Ann. Med. No. v. p. 149.

CHAPTER XVI.

EFFECTS OF EXPOSURE TO CLIMATIC VICISSITUDES.

Those most exposed to sudden changes of temperature suffer most from malarious fevers—Pringle's observations—Private soldiers suffer more than officers and latter more than civilians—Each class attacked by same diseases—Many attempts to explain this difference but none of them satisfactory—Alcohol is not malaria—Drunkenness often leads to exposure to climatic influences—When this is avoided drunkards scarcely more liable to fever than sober men—Cases in point—Exposure on night duty great cause of sickness amongst soldiers—Observations of Messrs. Snell, Hensman, and Morgan, and Drs. Davy and Murchison—Also of Sir J. Pringle and Mr. Hennen—Mr. Gore, on fever at Sierra Leone—Dr. Livingstone's experience—Cases of malarious fever from exposure on board ship—Effects of exposure to rain in tropics—Mr. Hare's observations—Lind's and Humboldt's remarks—Native servants in India often suffer from fevers during cold and wet weather, when their white employers escape—In some cases those exposed to climatic vicissitudes attacked by fever, while others not so exposed escape—Instances.

From what has been said, in previous chapters, of the origin of malarious disease, it is to be expected, that those must suffer from it most frequently and most severely, who are exposed in the greatest degree to climatic influences; and this is everywhere the case.

In epidemics of malarious fever, the greatest sufferers are always the worst clad, worst sheltered, and least protected from vicissitudes of temperature. The same thing is to be observed in the numerous isolated cases of the diseases referred to, which so constantly occur, especially in hot climates.

When troops are attacked by malarious disease, whether in cantonments or in the field, the private soldiers suffer to a very much greater extent than their officers; though all breathe the same atmosphere and so should inhale the same poison, if poison there were. The reason of this is, that the soldier is often exposed to sun and to rain, with few opportunities of changing or drying his clothes, and to chill, night air, and heavy dew; often sleeping in camp on the damp ground, or in the guard room in his wet clothes: while the officer is not nearly so much exposed to these influences, and

his means of protecting himself from vicissitudes of climate are much greater.

In Pringle's time, as might be expected, the men, who had neither great coats nor blankets, suffered very severely. That author, writing of the fever in the army in Holland, observes: "The officers were not so subject to it as the common men, being less exposed; and for the like reason the cavalry who had cloaks to keep them warm in the night, were less liable to fall ill; others who belonged to the army, but lay in quarters, were least of all affected; and the less in proportion to their being exposed to heats, night damps, and bad lodgings."*

The British soldier is much better off now, than he was, but still he suffers very much more than his officers from malarious diseases; and the reason is the same as it was in Pringle's time.

In many cantonments in India, we have opportunities for comparing the health of the troops with that of a white civil population, and the difference is very striking.

During the 20 years, from 1814 to 1833, the mortality amongst the non-commissioned officers and men of the army in India was 83 in 1000 annually.†

Amongst the officers during the same period, the mortality was 38 in 1000.†

In the Indian Civil Service, the mortality during the first 20 years of service in India, was 20 in 1000.†

The official document from which I quote, says, of the officers: "the diseases were undoubtedly of the same character, and were in fact the same, as those which kill the soldier."† And again, "The diseases of the civil servants, from which they enjoy immunity in England, are known to be the same as are fatal to the soldier."†

Thus the diseases of the civilian and those of the soldier are the same, differing only in the degree in which they prevail. If "malaria" were a specific poison, it would be indeed

* *On the Diseases of the Army*, i. 3, 24.

† *Report of Royal Commission on Sanitary State of Army in India.* i. xix. xxi.

surprising, that it should show such a strong partiality for one class of the community.

Many attempts have been made to explain the excessive liability of soldiers to malarious disease. It has been attributed, and sometimes justly, to the position and construction of barracks; but barracks are not always badly built, nor always placed in the most unhealthy positions; yet the soldier invariably suffers more than his officers; and very much more than civilians. Pools of water, trees, weeds, and the presence of organic matter in wells, have been blamed; but the civil population of the cantonment are equally exposed to these. Excesses in eating and drinking have also been alleged as causes of the greater prevalence of disease amongst soldiers. But these will not account for malarious fevers. Moreover there are few white men in India, who eat less than soldiers, and certainly very few officers who do not eat more.

I have known five healthy young officers, who had clubbed their rations on a march, eat their whole daily allowance for breakfast.

The uninitiated, when they hear of the soldiers's pound of of meat, are apt to imagine a pound of "juicy steak;" but it may be well to bear in mind, that Indian bullocks are not prize cattle, and that the bone, which is developed to an extent rarely if ever seen in England, is included in the ration; sometimes forming a large proportion of it.

Brigadier General Russel, who appears to have understood, that men are most healthy when well fed, says: "We had a regimental arrangement, and made a contract every quarter, for the purpose of supplying each man with 8oz of mutton for his breakfast, and for the evening meal 6 oz. of bread, in addition to the full ration which was supplied by the Indian government." And he adds: "I do not suppose that came up to what the officers were eating."*

In the Bengal Artillery, which was always the healthiest corps in India, a similar arrangement existed, and the men prided themselves on their good living.

* *Report of Royal Commission of Sanitary State of Army in India.* i. 233.

It is very certain, that none of those officers, medical or otherwise, who have considered the soldiers ration excessive, ever tried the experiment of living upon it.

In India, as elsewhere, other things being equal, the healthiest men are those who are best fed; and whatever may be said to the contrary, the rice-eating Bengallee is not physically equal to, nor does he live longer, nor suffer less from fevers, than the meat-eating Pathan or the liquor-loving Sikh.

Dr. Livingstone's views, founded upon extensive personal experience, are no doubt correct, viz. that the best preventives against fever are plenty of interesting work to do, abundance of wholesome food to eat, and to be well-housed, and well-clothed.*

It would be a great mistake to imagine that sickness, in the tropics any more than in England, or amongst soldiers any more than in civil life, is confined to drunkards; although, from much that has been said and written on the subject, it might be supposed, that almost all tropical disease was caused by some action of alcohol upon the system; that sober men had little to fear; and that they might expose themselves to climatic influences, almost with impunity. Such an idea as this is far from being correct, and would, if acted upon, soon lead to fatal consequences.

The moderate use of fermented liquors, in malarious countries, is undoubtedly highly beneficial; and although drunkenness does increase the liability to the diseases referred to, it only does so indirectly by means of that reckless exposure to climatic influences, to which men in a state of intoxication are so subject. Thus we are told, that "intemperance in the use of partially fermented and drugged liquors, with *subsequent exposure to cold, wet and malaria,* may be set down as the principal sources of disease, amongst the European soldiery at Cannanore."†

The steadiest man does not escape fever; while, if he be fortunate enough to avoid exposure, the drunkard does

* *Expedition to the Zambesi*, iii. 72. † *Madras Topographical Reports*, 1844.

not suffer more from malarious disease, than his sober comrades. When serving with the Bengal Artillery, I had many opportunities of observing this; others, too, have noticed it. At Hong Kong, in 1864, the 99th Regiment suffered very severely from malarious fevers; yet, the surgeon remarks: "The sanitary condition of the prison cells has been most satisfactory, and the health of the prisoners, most of them drunkards, has been better than that of the men at their duty; I attribute this, and their immunity from fever, to the fact of their having no night exposure."*

In this instance the drunken men were amongst the few who escaped sickness.

No one supposes, that drunkenness is beneficial, or that it is not injurious, but it is not "malaria;" nor would the soldier escape malarious disease, if he were restricted to "light wines." The sickness and mortality amongst the soldiers must be greater, than amongst their officers, so long as the former are, as they were in Pringle's time, "more exposed" to all vicissitudes of climate.

A great proportion of the sickness amongst soldiers arises from carelessness, and ignorance of the dangers around them, but a greater proportion may be traced to exposure on duty, and especially on night duty. Officers have but little of this; civilians none at all.

Davy observes, that between 1821 and 1834, H.M. 51st regiment, in the Ionian Islands, lost 81 men from remittent fever, but only one officer; and he remarks, that the men were exposed at night, but the officers were not.†

Mr. Snell, surgeon of the 99th Regiment, says: "during the time the regiment was at Hong Kong, I noticed immunity from fever, of all men who were not liable to night exposure, namely the staff sergeants, hospital staff, orderlies, men of the band, messengers, privates in staff employ and others." And he adds: "the garrison prisoners were always the most healthy men in the garrison, and hardly ever suffered from fever."‡

* *Parliamentary Report, China*, 1866, 275.

† *Medical Topography of the Ionian Islands*, &c. 250.

‡ *Parliamentary Report, China*, 1866. p. 4.

Assistant Surgeon Hensman says: "The scale of liability is clearly manifest, the duty men suffering soonest and oftenest, the non-commissioned officers next in order, then the bandsmen, and least of all, the officers. The officers are not quite so free from fever as the merchants; these last maintain the highest condition of health in the colony."*

All the year round, whether the season be hot, cold or rainy, healthy or unhealthy, the soldier is exposed at night on guard; and this is the main cause of sickness amongst the native, as well as amongst the white troops; but is of course most deadly to the latter.

The first part of the night is often hot and sultry; the lightest covering is almost unbearable; the temperature then falls; the men's clothing, already wet with perspiration, becomes drenched with dew; their bodies are thoroughly chilled: and next morning, or perhaps a day or two later, some of them are admitted into hospital, with fever, dysentery, or hepatitis.

There could scarcely be a more striking example of the effects of exposure to climatic vicissitudes, in the production of malarious disease, than was afforded by the excessive sickness and mortality amongst the troops at Hong Kong in 1865-6; on a barren rocky island, so free from all usually supposed sources of malaria, that, in their absence, the crumbling granite was believed to exhale the "paludal poison."

The Surgeon of the 99th Regiment says: "Intermittent fever is the prevailing disease; due to some unexplained and unfathomable influence of the soil; as near the situation of the barracks there is neither swamp, marsh, nor jungle land. That the predisposition to fevers is mainly induced by night exposure, I have not from my experience the slightest doubt. It is most prevalent during the summer months."†

It is clear then, that no marsh poison was the cause of the fevers at Hong Kong. Yet they were "mainly

* *Army Medical Report*, 1866.

† *Parliamentary Report, China*, 1866. p. 241.

induced by night exposure." In other words, by the effects of nightly damp and chill, upon men who were highly predisposed to disease, from constant exposure to intense heat during the day. As has been already shown, the men most subject to these influences suffered most, and those not exposed to them scarcely suffered at all.

It is undeniable that night exposure is injurious in all malarious countries, especially in the unhealthy season, and, so far as white men are concerned, more especially in hot climates. It is also certain, that the danger of such exposure arises from *chill.*

Mr. Morgan, Surgeon of H.M. 57th Regiment, quoted by Dr. Chevers, says, with regard to draughts of cold night air, that speaking from long directed attention to this subject, he does not hesitate to declare, "that all the causes of disease among British soldiers in India, sink into insignificance when compared with exposure to nocturnal variations of temperature."*

The civilian carefully avoids night exposure, and so to a great extent does the officer, who has only to visit the guards once or twice in the night; and that only occasionally, as his turn comes round. The poor soldier on sentry, however, must remain at his post, through heat, cold or wet, however wretched he may feel; nor does he, when on night duty, receive an extra ration, a dram, or in most cases even a cup of coffee; but is exposed with an empty stomach, to the influence of damp and chill, or, as it is called, "malaria."

Dr. Murchison observes, that "many of the men were first seized with fever when on sentry duty at night."†

The same writer says: "we have seen that during the months of November and December, the mornings at Prome were peculiarly chilly, and we may mention that most of the fever patients, who could give any cause for their illness, attributed it to cold caught during a night march, or from throwing off their jacket on returning from parade in the morning, or from exposure to a cold draught during the night."†

* *Health of European Soldiers in India.* Ind. Ann. Med. 1861.

† *On the Climate of Burmah*, 24.

Pringle remarks that, in Holland, "no epidemic ever ensued upon the greatest heats, till the perspiration was stopped by wet clothes, wet beds, dews, and fogs; and then some bilious or putrid distemper was the consequence."*

Since Pringle's time, many observers have noticed the certainty with which, malarious diseases follow exposure to chill.

"Much has been said," observes Hennen, "of the unhealthiness of the barracks at Vido. The malaria from Bucintro was supposed to affect them. This I doubt, for on its passage of 12 miles over the bay, much of its baneful properties would be absorbed by the water, and much of them be diluted and dissipated by the winds. Besides, the prevailing winds do not blow from the marsh, and if they did, the barracks are screened from their effects; while the citadel, which is more directly exposed to the winds blowing from Bucintro, is free from malaria. I am convinced that the unhealthiness of Vido, has been principally owing to the excessive changes of temperature experienced by the troops quartered in the wooden barracks, which were intolerably hot in the day, and piercingly cold at night."†

Staff Surgeon Gore, in his interesting sketch of the Medical History of Sierra Leone, observes: "With the exception of cases occuring during epidemics, most of the worst forms of remittent fever at Sierra Leone, are due to exposure, or any cause which suddenly disarranges the usual combining together of the vital processes, such as a wetting; bathing in the sun; or a debauch, with *subsequent exposure to the dew and night air;* which quickly checks, probably a profuse perspiration, and suddenly increases the effete matter in the blood, already loaded with impurities and germs of disease."‡

Dr. Livingstone frequently alludes to the effect of exposure to chill and damp, in producing malarious fever. "I had," he says, "attacks of fever of the intermittent type, again and again, in consequence of repeated drenchings in these un-

* *On Diseases of the Army* ii. 2. 72.

† *Medical Topography of the Mediterranean.* 213.

‡ *Army Medical Report,* 1867.

healthy spots."* Again he says: "At Tete, a sudden change of temperature happening on the 4th April, simultaneously with the appearance of the new moon, the commandant and myself, with nearly every person in the house, were laid up with a sudden attack of fever."†

In describing his journey to the east coast, when he and his party suffered but little from fever, Livingstone says: "In Londa we braved the rain, and as I despised being carried, in our frequent passage through running water, I was pretty constantly drenched; but now, when we saw a storm coming, we invariably halted. The men soon pulled grass enough to make a little shelter for themselves, by placing it on a bush, and having got my camp stool and umbrella, with a little grass under my feet, I kept myself perfectly dry. We also lighted large fires, and the men were not chilled by streams of water running down their persons and abstracting the heat, as they would have been had they been exposed to the rain. When it was over, they warmed themselves by the fires, and then travelled on comfortably. The effect of this care was, that we had much less sickness, than with a smaller party on journeying to Loanda."‡

Here, we have, contrasted, the results of different degrees of exposure to climatic vicissitudes, in an unhealthy country.

Are such precautions as these, so successfully employed against "malaria," likely to avail against any specific poison, however dense, or however subtle? could they avail against anything but chill?

Naval surgeons frequently notice the intimate connection between malarious fevers and exposure to cold. Some instances of this have been referred to.

The Surgeon of H.M.S. Assurance, on the Coast of Africa, reports that several cases of fever occurred, in Kroomen (negroes), from the effects of sleeping on the upper deck without sufficient covering: the men having sold the blank-

* *Travels in Southern Africa*, 283.

† *Ibid.* 647.

‡ *Travels in Southern Africa*, 572.

ets with which they had been provided. One Krooman, who had been away on boat duty without his blanket, was seized with fever, of very severe type, complicated with pleuro-pneumonia.* Here, fever followed exposure to chill, in the case of men, who in their native climate are of all races least liable to suffer from the effects of "malaria;" and who, on board ship, could be but little exposed to any "marsh poison." In the worst case, too, the fever was, as is often the case, complicated with a disease which is universally admitted to arise from cold.

Dr. McWilliam mentions, that in the Niger expedition, the first cases of fever were amongst the black seamen of the "Wilberforce," who were exposed to rain and rough weather while taking in water.† No one else was attacked, on board any of the ships, for some three weeks after this.

On board H.M.S. Nimble, in the West Indies, 118 cases of remittent fever were ascribed by the surgeon mainly to exposure to climatic influences. The ship having been blown ashore in a hurricane, remained for 53 days; during which time, the men had to undergo great hardships; working night and day in laying out anchors, &c.; and being employed for a great part of the time in the water.‡

The Surgeon of H.M.S. Bulldog, on the West India station, observes: "However, on all occasions when men were exposed to rain, even for a short time, some cases of fever occurred, those most readily affected being such men as had already suffered from one or more attacks of this disease."§

As to the results of exposure to rain, Mr. Hare, surgeon of the 2nd Bengal Fusiliers, observes, that in Burmah, as well as during the siege of Delhi, in the rainy season, he was much struck with the suffering of the men from wet clothes; and that the constant history of the most severe cases of fever and dysentery, on admission into hospital, was: "I was

* *Naval Medical Report*, 1867.
† *Niger Expedition*, 175.
‡ *Naval Medical Report*, 1867.
§ *Ibid.* 1865.

quite well sir till I got wet, and was obliged to lie in my wet clothes all night on picket."*

The effect of exposure to the chilling influence of rain, in producing intermittent and remittent fevers, which has been several times alluded to, is well-known to the inhabitants of all hot climates.

Lind mentions that the negroes and mulattoes of the Gambia carefully avoid being wetted by the rain, especially when the first fall occurs.† The Indians of Honduras do the same.

Humboldt observes, with regard to malarious fevers: "Whole families of free negroes, who have small plantations on the northern coast of the gulf of Cariaco, languish in their hammocks from the beginning of the rainy season." And he adds; "These intermittent fevers assume a dangerous character, when persons debilitated by long labour, and copious perspiration, expose themselves to the fine rains, which frequently fall as evening advances."‡ The natives of India have a great dread of rain, especially at night, or in the cold season. I have known my servants fast for twenty-four hours in cold weather, rather than walk a couple of miles through a heavy downpour to buy food.

It is the cold and damp, that is dreaded at such times, and not any specific poison.

The effect of exposure to damp and chill in producing malarious disease, and the influence of clothing and shelter in warding off its attacks, are strongly shown in those instances, so often observed in India during wet and cold

* *Report of Royal Commission of Sanitary State of Army in India*, ii. 185.

Mr. Hare remarks: "It has often struck me as wonderful, that in these days of chemistry and improvement, nothing has yet been done to protect the soldier from wet."

It is indeed extraordinary that this important subject should have received so little attention from sanitarians; and that the soldier's great coat, his only protection from rain, should be contrived so as to absorb water like a sponge, when it might be rendered waterproof at the cost of a few pence, and without any injury to the material or color, by means of a solution of Alum and Sugar of Lead.

† *On the Health of Europeans in Hot Climates.* ii. 51.

‡ *Narrative of Travel.* viii. 286.

weather, of the greater part of the native servants of an European household being attacked with fever, when all the members of the family escape. All these people breathe the same atmosphere; in most cases, all drink from the same well; and the climate of the country is generally more favourable to the native, than to the white man: yet, at the times referred to, the former suffers most. The cause of this difference is, that the whites have good houses, sufficient clothing, and perfect protection from wet and chill; while the native servants are obliged to walk about in thin cotton garments, and often to sleep in them, while still damp. The prevalence of fever amongst the lower classes of natives, in India, is often attributed, and in some cases justly so, to the habit so common amongst them, of sleeping in the open air; but during the "rains" they rarely do so; moreover, in the cold climate of the upper Himalayah, where they sleep indoors, with every crevice carefully closed, the ill-clad natives from the plains, suffer even more from fevers, than they do in the low country.

So generally is the wet and cold of the hill climate recognised, as the cause of the fevers prevalent amongst the native servants, that, it has become the custom, at most hill stations, as the only means of preserving them in health, to provide them with warm woollen clothing. In cold and wet weather, therefore, the white man well protected from damp and chill, has often a better chance of escaping attacks of malarious fever, than the native of India without such protection. This could not be the case if malaria was an organic poison; nor if the cause of malarious disease, was anything else but chill.

It constantly occurs, in malarious countries, that fever attacks those only, who have been exposed to influences which tend to the rapid abstraction of animal heat; while others, who have not been subjected to such agencies, escape the disease. And this, to several instances of which I have already referred, may take place in people dwelling in the same district, and even on the same spot, breathing the same air, and who would be equally exposed to the action of any

specific poison, if such existed. Thus at Goojrat, although as already noticed, the prisoners who were carefully protected from cold and wet, were almost entirely free from malarious fever; the native military police, who were on guard at the Jail, and who were exposed on sentry duty night and day in all weathers, suffered severely from that disease, especially in the rainy season, and afterwards, when the country was drying up and the nights were damp and cold.

In describing the sickness in the 2nd Bengal European Regiment, at Prome, Dr. Murchison observes: "During the first three months, there were only two officers attacked by fever, and these were attacked under the following circumstances. On Sunday, Nov. 27th, these two rode down to Shoaydong, eight miles distant, had a late dinner there, and at 11 P.M. started for Prome again, by the river, in an open native boat. They were three or four hours rowing up against the current; and having neglected to take their cloaks with them, arrived at Prome, drenched with dew, and very cold. On the Tuesday following they were both attacked by intermittent fever, which lasted for some days."*

My first attack of fever occurred in Central India, in the month of November, after a thorough chill caused by sleeping, with insufficient covering, in a draught of air between two open doors. The day before this I was in perfect health, and I had been into no malarious locality. Another officer slept in the same house, and some twenty native servants lived on the premises, several of them sleeping in the open air; but no one else was attacked with fever.

Sir Samuel and Lady Baker, on board their comfortable boat, with plenty of good food, dry clothing, and shelter from the weather, passed through the swamps of the White Nile in safety; though their native boatmen, from being frequently wet, suffered severely from fever, and the people of the country are described as fever-stricken wretches. Afterwards, when exposed to constant rain, without change of clothing, with indifferent shelter, and suffering from hunger and fatigue,

* *On the Climate of Burmah*, 25.

these adventurous travellers nearly lost their lives from fever, on a tableland some 4000 feet above the sea.

Dr. Livingstone mentions, that while passing through a country, which was damp and partially flooded from heavy rain, after having, for some time, had the thermometer at 98° in the shade, and 138° three inches below the surface of the ground, the natives who travelled with him were all but one attacked with fever; but he himself escaped.* It could not be supposed, that the doctor was less liable to the action of any poison, than the native Africans; but he slept in his waggon, sheltered from the nightly chill, the natives sleeping on the damp ground round a fire. Afterwards, when all were alike exposed to sun and rain, heat and chill, the white man suffered most.

H.M.S. Griffon was lost on the west coast of Africa. The crew were landed; those on the sick-list were taken into the house of a coloured trader; the rest remaining in tents on the beach. Two days after, some of the crew were sent on board another ship, and most of these escaped disease. The remainder stayed from nine to twelve days on the beach; during which time the tents were soaked in a tornado. Of those who slept during this time in the tents, not one escaped fever; while of the sick located in the trader's house close by, not one was attacked.†

In 1860, at Jhansi, a very hot, barren, and rocky station in Central India, the wing of a native regiment, 400 strong, came under my charge. On 8th May, there were but six men on the sick list, and of these only two or three had fever. There being no quarters available, the sepoys were encamped on the elevated plain, upon which, the barracks of the white troops were built; but at a distance of about a quarter of a mile from them.

The site of the camp was dry, stony and, with the exception of a few thorny bushes, destitute of vegetation. The nearest well was some 50 feet deep. There were no trees on

* *Travels in Southern Africa*, 167, 168.

† *Naval Medical Report*, 1866.

the ground, and but few within reach; so that, as there was no shade, the men, who were all Hindoos, were exposed with bare heads and naked bodies to a noonday sun, while they cooked and ate their food; and several febrile attacks and cases of headache were the immediate consequence.

Early in July the rains set in; and the fall of temperature was great and sudden.

At once, a number of cases of fever occurred; and in a few days the hospital was crowded with cases of intermittent and remittent. Tents were used to supplement the hospital building, and these were soon full. Within a month from the setting in of the rains, 100 men were sick in hospital, and as many more convalescent, but unfit for duty; and in September, the regiment was excused from all duty and parades, scarcely a single man having escaped fever.

At this time there was no unusual sickness in the two other native regiments quartered in the station, and on lower ground. In the Battery of Artillery to which I belonged, out of 115 white men there never were more than five or six cases of fever at a time in hospital. In the European Infantry regiment, the proportion was about the same.

What then could be the cause of the great sickness amongst these native soldiers? Why should they have suffered so much more severely, than the men of the European corps, at the same station, on similar ground, and at a distance of only a quarter of a mile?

The only apparent reason was, that the sepoys, after being exposed in tents for two months at the hottest season, on a dry, bare, piece of rocky ground, the heat reflected from which was intense, were suddenly exposed to a great fall of temperature; the effects of which were intensified by the heavy rain, which soaked the tents and wetted everything in them. So that, after having been subject, for a considerable period, to very great heat, these men were suddenly exposed with damp bedding and clothes, on saturated ground, to the chill night air, rendered more bitter by the wind blowing through the wet tents.

The other native regiments, which retained excellent health, were quartered in dry and comfortable huts.

Quarters were at last provided for the sickly sepoys, but for a long time they could not shake off the fever, and late in October, when they were removed to another station, four-fifths of the men fell out on the first march, from fatigue and exhaustion.

At the time the sepoys were suffering so severely from malarious fever, their European officers, who had built for themselves a snug little bungalow before the rains set in, enjoyed excellent health; although their house was only about 100 yards from the men's tents, and on ground precisely similar to that on which these were pitched.

Numbers of such cases might be cited, but they would present merely a repetition of the same incidents.

Sufficient evidence has been produced to show, that so-called malarious fevers may be caused by chill; and this being the case, there can be no necessity for supposing the existence of a poison, which all the researches of chemists and microscopists have failed to discover; but which, like its relative "Will o' the Wisp," has often served to lure explorers from the path.

CHAPTER XVII.

BOTH PRIMARY AND RECURRENT ATTACKS OF MALARIOUS FEVER RESULT FROM SUDDEN CHANGE FROM HEAT TO COLD.

Paroxysmal fever often makes its appearance upon a sudden change from a hot to a colder climate—Especially if effects of change be heightened by exposure to wet or a cold wind—This effect produced even when the change is to a most healthy locality—Persons in India attacked with fever for first time on arrival at Hill Sanitaria—Same occurs in Mexico—Same thing happens in Europe to persons arriving from hot climates—Instances—So-called relapses of malarious fever arise from chill—Dr. McLean's remarks—Dr. Waring's observations—Instances of recurrent attacks of intermittent, after long intervals, in consequence of exposure to cold—Observations of Surgeon Major Small and Assistant Surgeon Power on recurrent attacks of intermittent in H.M. 13th Regiment—Liability to recurrence explained.

From what has been said in previous chapters of the origin of malarious fevers, the frequency with which these diseases appear, upon a sudden change from a hot to a cooler climate, will be readily understood.

Instances constantly occur of malarious disease making its appearance, under the circumstances named, in persons who have shown no previous tendency to it; and this, even when the removal has been to a most healthy locality. People are especially liable to suffer in this manner, in whom the effects of the change have been heightened by exposure to cold or wet.

I have known several instances in which individuals have been attacked with malarious fever, for the first time in their lives, after their arrival at a Hill Sanitarium, in consequence of insufficient protection from rain or cold winds on their journey from the plains; or from neglect of proper precautions against chill, on their arrival in the cooler climate. For instance, an officer of the Public Works department, who had never suffered from fever, and was in good health when he set out, got wet and chilled on his way up to Dalhousie, where he was attacked with intermittent, on the night of his arrival. Another gentleman, who had never suffered from fever,

and who was in excellent health when he set out from the plains on a short visit to Dalhousie, having missed his servants and baggage on the road, arrived there without bedding or warm clothes. As the hotel at that station, like many others in India, was not furnished with bedding, this gentleman lay down on a sofa before a good fire and fell asleep; towards morning, the fire having gone out, he awoke thoroughly chilled and, a few hours after, was attacked with intermittent fever.

The road to Dalhousie, passed through no Terai, or unhealthy jungle, and, in the first of these cases, the whole journey was made by day.

M. Jourdanet has noticed, that in Mexico, similar results, with regard to both fevers and dysentery, sometimes attend a sudden change from the low country, where the heat is intense, to the comparatively cold climate of the elevated plateaux. This writer says; "Thus, individuals in perfect health, and who have always remained so, in the hot marshy countries of the sea coast, proceed suddenly to the highlands. A few days after, they are attacked with intermittent fever." "These affections," it is further noticed, "which thus attack new arrivals at Mexico, are the more worthy of attention, as maladies of this kind are rarely observed there, resulting from local influence."*

M. Jourdanet considers these diseases, when they occur in new arrivals in the elevated districts of Mexico, to be owing to the development of the malaria absorbed in the hot regions of the coast. But he admits that many of the individuals so affected had always enjoyed good health on the coast; that they continued in good health on the journey; that they arrived in the same condition at Mexico; and that only after their arrival in the colder climate of the plateau, did any symptom of the disease appear.

It is clear then, that whatever may have been the predisposing influence, the exciting cause was the sudden change to a comparatively cold climate. And it is tolerably certain, from what I have already shown, that the only predisposing agent was the

* *Les Altitudes de l'Amerique Tropicale*, 261,

previous continued exposure to a climate, so uniformly and intensely hot as that of Vera Cruz.

M. Armand observes: "Many soldiers after campaigning in Africa, where they have enjoyed good health, returning to France in the cold season, will be seized with an attack of intermittent fever, to which till then they had been strangers. The fact was not rare amongst the military surgeons, who passed rapidly each Autumn from the ambulances of Algeria to the hospitals of Strasburg, Metz, or Lille."*

This predisposition to malarious fever on exposure to cold is gradually lost, as the heat-generating powers recover their equilibrium, in a cool and equable climate; but if the chilling influence be powerful, an attack of intermittent may often be induced, after a very considerable lapse of time. Thus it is mentioned, in the report of the medical officers, that two soldiers of the 13th Regiment, who had passed safely through the epidemic at the Mauritius, were attacked with intermittent, at intervals of five and six months after leaving that island.† The men were stationed at Portland, where they were employed on guard over the convicts, and when on this duty, being placed in commanding positions, they were very much exposed to cold winds.

It may be said, that the constitutions of these men might have become affected by "malaria" at the Mauritius, and that the poison might have been retained in their blood; but apart from the extreme improbability of any poison lying dormant for so long a period in the system, it is certain that no living germ, nor product of animal or vegetable decomposition, is vivified and fertilised by exposure to simple cold, in a pure and bracing atmosphere, such as that to which these men were exposed at Portland.

From the foregoing observations, it is evident, that malarious disease may be developed in persons who have shown no previous tendency to it, by exposure to chill upon a sudden change from a hot to a colder region; although the cooler climate may be healthy and invigorating to those whose systems have not been affected by previous long-continued exposure

* *L'Algerie Medicale*, iv. 143. † *Army Medical Report*, 1866.

to great heat, or even to those who, having been so exposed, take proper precautions to maintain the temperature of the body.

When, under similar circumstances to those I have mentioned, an access of malarious fever takes place, in a person who has previously suffered from a similar attack, it is considered as a relapse; though months and even years of health may have intervened. In most forms of disease it would be thought preposterous to call another attack, after the intervention of years of health, a relapse. But whether it be called a relapse, or a recurrence, exposure to chill is the cause.

It is admitted by very eminent authorities, that a "relapse" of malarious fever may be brought on by exposure to cold or wet, without any fresh exposure to malarious poison; and that this may take place after an interval of weeks, months, or even years of health.

Dr. McLean says truly: "The heat-generating power of all victims to malaria is impaired, hence they suffer from atmospheric changes, of which healthy men take no note."*

Dr. Waring observes: I am far from wishing to damp any man's hopes, but you should be aware beforehand, how difficult it often is, to get rid of these tropical malarious fevers, even when unaccompanied by any abdominal complication, and when the best directed efforts, medical and hygienic, have been employed to eliminate the malarious poison. I have met with men who have been at home for a dozen years or more, who ordinarily seem well enough in health; but who on an incautious exposure to the inclemency of the weather, or after some error in personal hygiene, almost invariably suffer from an attack of their old enemy."†

I know a gentleman who suffered from intermittent fever in the West Indies, more than ten years ago, and who since his return to England has been several times attacked by the same complaint on exposure to a slight degree of chill, though

* Reynolds *System of Medicine*, i. 60.

† *The Tropical Resident At Home*, 225.

for several years he has never left the neighbourhood of his own house; which is in a remarkably healthy situation.

A lady who suffered severely from intermittent fever, some years ago at Rome, almost invariably has a recurrence of it if she is exposed to a cold easterly wind; although, she lives in a very healthy neighbourhood at the west end of London, where no fresh absorption of poison is possible. An officer, who had suffered severely from fever in India and in Abyssinia, told me that when staying during the summer in the lake district, he found that every time he went to a picnic party, an attack of ague came on in the evening, from exposure to the chilly air; though no one else was affected by it.

Another officer of my acquaintance, who had suffered from fever in India, was attacked with intermittent immediately on his arrival in London, from Ireland; having suffered much from cold, during the latter part of the railway journey.

I have already shown, that persons who have remained altogether free from malarious fever in hot climates, may be attacked by it on a suddeu removal to a colder region; it is not surprising therefore, that those who have suffered from the disease, but who have been free from it for years, and remained in perfect health while in a tropical climate, should be frequently attacked by intermittent, from exposure to chill, after their arrival in England.

Such was my own case. I left India in good health, and had not suffered from fever for more than seven years; yet last winter, after exposure to a cold wind, I had an attack of ague in Loudon.

An Indian officer, a strong active man, who had not suffered from fever for more than three years, landed in Englaud in May; a few months afterwards he visited one of the hydropathic institutions, where he remained for some time. A few days after leaving this institution, in cousequence apparently of exposure duriug a long drive at a chilly season of the year, he suffered from a severe attack of intermittent.

Another officer who had not suffered from fever for four years, was attacked by it between seven and eight months

after leaving India, during a course of sea-bathing, in the south of England.

A number of Indian friends whom I have questioned on this subject, have suffered from attacks of intermittent fever in England; although in some cases, they had not suffered from that complaint for several years previous to leaving India. These attacks have been invariably attributed to chill; and it is worthy of notice, that most of them, in London and elsewhere, have occurred in the evening or at night. This tendency may serve to account for the frequently supposed connection between dinner parties and relapses of intermittent.

On the return of the 13th Regiment from the Mauritius, after having suffered severely during the epidemic of fever in 1866, a great number of "relapses" occurred. The medical officers of the Regiment, Surgeon Major Small, and Assistant Surgeon Power, found from a long series of careful observations, that every fall of temperature was followed by an increase in the number of fever cases; and that, when the lower temperature became stationary, the number of cases gradually diminished; while with a further fall they again suddenly increased. This took place over a period of a year or more after the return of the regiment to England.

It was observed, that mild damp weather did not increase the sickness, but that cold, whether damp or dry, invariably did so, and that a sharp frost caused a very large number of cases of intermittent.*

No doubt, in those who have suffered from malarious fever, and especially from repeated attacks, there is an impaired state of the heat-producing powers, or in other words a diminished power of resisting the effects of cold; and this condition it is, which causes the great tendency to a recurrence of the complaint, on exposure to a very moderate degree of chill. This state, in most cases, passes off gradually as the health improves, after a longer or shorter residence in a healthy climate; but it occasionally remains for a very long time.

* *Army Medical Report*, 1866.

It is then admitted, that a great sensibility to cold predisposes to, and that exposure to chill causes, the so called "relapse" of malarious fever. But, as I have already shown, these are the very influences which produce the primary attack.

Thus, an impaired state of the heat-generating powers is produced by continued exposure to great heat; and this renders the system highly sensitive to the effects of chill.

Then, the seasons at which malaria is most prevalent, are those in which comparative cold succeeds rapidly to the greatest degree of heat; and in which the vital powers, depressed by the previous high temperature, are least able to resist the effects of the rapid alternations of heat and cold. Night is the most deadly time, and especially the latter part of it, when the animal powers are at their lowest, and when, from the general loss of heat by radiation, they are tried to to their utmost to maintain the temperature of the body. In the situations in which "malaria" is most commonly met with, the already overtaxed heat-producing powers have also to contend with the intensely chilling influence of damp. It is moreover found, that the measures which afford the greatest protection against the evil influence of "malaria," are those which tend to preserve the body from violent alternations of temperature. In short, it is clear that the cause of malarious fevers is chill.

Thus, each attack of intermittent or remittent fever, whether primary or secondary, arises from the operation of same cause: while the increased liability to recurrence, after frequent or severe attacks, is owing, not to the presence in the system of any dormant poison, but merely to a depressed state of the heat-generating powers, similar to that which is produced by continuous exposure to great heat.

CHAPTER XVIII.

BENEFICIAL EFFECT OF CHANGE OF CLIMATE IF PROPER PRECAUTIONS BE OBSERVED.

Occasional change to a cooler climate necessary to maintain the health of white men in the tropics—Observations of Sir A. Tulloch, Sir J. R. Martin, M. Thevenot and Dr. Morehead—Advantage of temporary removal from presence of great heat always admitted, even when malaria was considered to be a specific poison—Precautions necessary in case of sudden removal to a cooler climate—Such removal most powerful remedy for malarious fevers—Very slight change of temperature often sufficient—Beneficial effect of change of climate explained—Situations in which recovery is certain, in hot season, may, in cold season, produce an opposite effect—Dr. Morehead's observations—Benefit not produced by removal from presence of any poison, nor from any action of mere cold—In some cases change to a warm climate more beneficial than to a very cold one, though malarious disease may prevail in the former and not in the latter—Case in point.

It may possibly be thought, that if malarious disease may be developed by change from the plains to the hills,—from a hot region to a comparatively cold one,—it would be better that the change should be avoided, this however is not the case.

The steady and certain deterioration of the whole system, which takes place in white men, when exposed to the heat of the tropics can only be resisted by occasional change to a cooler climate; and the more frequent the change, the less will be the injury to the constitution.

Sir A. Tulloch, than whom there could be no greater authority, says that a residence in an unhealthy climate must necessarily produce injury for every year's continuance, he also mentions the well-known fact that during a residence even in the healthiest stations in the plains of India, the constitution of the European soldier becomes deteriorated.*

Sir J. R. Martin observes: "But a certain amount of destruction and deterioration of European health must result from a residence at the stations in the plains, even if the soldiers were put into palaces."†

* *Report of Royal Commission on Sanitary State of Army in India*, i. 324–325.
† *Ibid.* i. 5.

In all hot climates, the same results of lengthened residence are observed. M. Thevenot, quoted by M. Boudin, says: "the mortality amongst strangers in Senegal appears to increase in proportion to their length of residence. No acclimatisation is possible. It is by flying, that the European merchants save themselves; it is by remaining, that the soldiers perish in numbers."*

Few who have lived in a hot climate, will doubt that these observations are correct; or that the residence during the hot season in the cooler regions of the mountain ranges, so ably advocated by Sir J. R. Martin, is the only measure likely to reduce the sickness and mortality in India, or in any tropical climate, to the European level. But, as this appears to be in many cases impossible, the next best measure for preserving the health of white men in hot countries, is the frequent change to a cooler region. As Sir J. R. Martin observes: "Even the removal for a month or two, has been found of advantage in obviating fevers, and in removing such fevers as had seized on the men in the plains."†

Dr. Morehead says with regard to the effect, upon convalescents, of a temporary residence in a hill climate: "The soldier will have become fitted for duty, he will be less liable to fresh attacks of disease, and when attacked, the disease will be of a milder type."‡

This beneficial effect of even a temporary removal to a cooler climate, has long been admitted in the case of officers, as the result of experience; even though malaria was supposed to be a specific poison quite distinct from climatic influence. I have shewn, however, that protracted exposure to great heat not merely enervates the body and undermines the constitution, as it has always been admitted to do; but is the most powerful predisposing cause of the various forms of malarious disease; that in fact to a great extent it is "malaria:" consequently, the value of frequent change to a cooler climate becomes more than ever apparent.

* *Traité de Geographie et de Statistique Medicales.* Tom. ii. 163.

† *Report Royal Commission on Sanitary State of Army in India.* vol. i. 14.

‡ *On Disease in India.* xxxiii. 732.

For the same reason the value of the recommendation of the Royal Commission, that one third of the whole force of white troops in India should be located in the hills, is more obvious than ever. When this recommendation is carried out, some of the most unhealthy positions are abandoned, and night duty is reduced to a minimum, we may hope that the sickness and mortality amongst the white soldiers will be reduced to as low a level as is possible, in the case of men serving in a climate for which their organisation is unfitted.

The occasional removal to a cooler region is then a necessary condition, for the preservation of health in the tropics; and if due care be taken it may be effected without risk. It is only when the transition is too great and sudden, in case of exposure to wet and cold, or when the precautions necessary to protect the body from chill are neglected, that any ill effects are to be seen.

The first step to be taken, in order to avoid the danger of transition from heat to cold, is to make the periods of exposure to the former as short as possible; and the others are, to provide proper clothing and shelter in the cooler climate; and to carefully avoid exposure to chill, until the system has become somewhat inured to the change.

Many hill stations have suffered in reputation, and very many men, both soldiers and civilians, have lost their lives, through the most complete neglect of these precautions.

All these remarks apply not merely to the change to a hill climate in India; but, in a greater or less degree, to a sea voyage; to the overland journey to England; or to any case of removal to a colder climate, when the system has been rendered sensitive to the effects of chill, by long-continued exposure to great heat, and especially when the vital powers are depressed, by the effects of frequent attacks of malarious fever

So far as regards the white race, removal to a cooler climate is not only the most effectual preventive of the malarious fevers of tropical regions; but it is pretty generally admitted, that it is the most powerful curative agent in these diseases; and that even the much vaunted powers of cinchona are weak when compared with the influence of this

potent remedy. Instances often occur in which fevers persist for weeks, in spite of large doses of quinine; and others are constantly met with in which, although the paroxysms for a time cease, they return again and again from the slighest cause; yet in these cases, the improvement produced by a judicious change of climate, is marked and immediate.

"The truth is," says Sir J. R. Martin, "that there are fevers, dysenteries, and chronic forms of hepatic and splenic disease, which no amount of medicine *can* cure, but which change of air *will* cure, with some degree of certainty."*

The effects, in obstinate cases of fever, of a few days at sea, or of removal to an elevation of a few thousand feet, are sometimes really magical; but a much slighter change is often sufficient.

What can there be in change of residence, (it may be to a short distance only,) to produce such results in this particular class of diseases? It is not that the cooler climate kills any germs, animal or vegetable, or destroys any poison circulating in the system; for I have already shown, that removal to such a climate does not benefit, if the cold be excessive. Nor can it be, that the improvement is caused by escaping from the presence of a specific poison; for malarious disease may prevail at the very place to which the patient is removed, and yet the good effect be produced.

It is wonderful how slight a change of temperature is sometimes found beneficial in cases of malarious fever; and this when, in other respects, the new locality is precisely similar to that in which the disease was contracted. About five miles from the station of Madhopore is the old fort of Shahpore, which is used as a sort of sanitarium by the residents of the neighbouring district. In point of altitude, soil, and distance from any supposed source of malaria, neither of these places has any advantage over the other; unless the latter, being close to the foot of some low hills covered with jungle, might be imagined to be more exposed to malaria than the former, which is quite open. Malarious fevers arise in both localities. Cases of

* *Influence of Tropical Climates*, &c, p. 287.

fever however recovered at Shahpore, which obstinately refused to do so at Madhopore; the sole apparent advantage of the former situation, being that its temperature is almost always some 2° or 3° below that of any other place in the neighbourhood. This comparative coolness is owing to the position of the fort, upon a cliff the foot of which is washed by the Ravee as it debouches into the plains. The temperature during the day is lowered by a draught of cool air, which accompanies the rapid current of the river; the water of which, derived in great part from melted snow, is very cold during the hottest months. And at night a cool wind, from the Himalayah, blows down the narrow rocky valley, opposite to the opening of which the fort is built.

What is required to render change beneficial, in cases of malarious disease, is an equable and invigorating climate, not invariably a colder one; although in the case of a white man in the tropics a lower temperature is generally necessary. Coolness is beneficial up to a certain point, depending upon the heat-producing powers of the individual; but when it amounts to chill, it ceases to be invigorating, therefore retards the cure, and may even aggravate the disease.

A native Indian when attacked with fever in the hills at any time, or in the plains during the cold season, is as much benefited by a change to a hotter climate, as is the white man, in the hot months, by removal to the hills. This could not be the case, if mere removal from the presence of "malaria" was the object to be gained.

As a proof that the benefit derived from change in malarious fevers is owing to the influence of climate, and not to mere altitude, or removal from the presence of a specific poison; it may be seen that the very places in which, during the hot season, recovery is almost certain, may, in the cold season, when the change is too sudden, or when the necessary precautions against chill are neglected, produce a contrary effect.

Thus Dr. Morehead obscrves: "Those who have become reduced in strength from recurrences of intermittent or remittent

fever at Poona,* or other adjacent stations, in June, July, August,and September, may, with advantage, reside at Poorundhur† from the beginning of September to the middle of November. After this period however, such cases had better be returned to Poona; for from the middle of November to that of February, there will be a greater liability to re-attacks of fever *in the hill climate than at Poona.*"‡ Again he says: "Individuals, who have suffered from frequent attacks of malarious fever, are liable to have the disease re-excited—chiefly in the tertian form—by external cold, in the months of December and January; this liability, (the degree of predisposition in both instances being assumed equal,) is greater at Poorundhur than at Poona; therefore the former locality should, under these circumstances, be avoided in these months."§

In those cases, in which persons, after long residence in hot climates and repeated attacks of malarious fever, have become subject to recurrences of intermittent, on exposure to the most trifling depressions of temperature,—when the system is said to be "saturated with malaria,"—it is constantly found that change, even to England, is of no benefit whatever in very cold weather; but that paroxysms of fever still recur. In such instances, the mere removal from the presence of "malaria" does not benefit, nor does the cold kill the disease; but a change to a milder climate, such as that of the south of France or Italy, is often immediately beneficial; and during a temporary residence in the more genial temperature of those countries, the heat-generating powers gradually recover themselves; so that the patient is after a time able to endure, and to benefit from, the colder climate of England.

The following case is an instance of the injurious effects of cold; and a proof that for a change of climate to be beneficial in a case of malarious fever, the temperature must be suited to the state of the heat-generating powers of the individual.

* Altitude 1800 feet.
† Altitude 4200 feet.
‡ *On Disease in India.* xxxiii. 748.
§ *Ibid.* xxxiii. 749.

An officer of Artillery, who had suffered from a very severe attack of intermittent, in the plains, but had become convalescent, with the exception of occasional slight paroxysms and great debility, was sent at the beginning of the mouth of November to Dalhousie; where the weather was at the time very cold, and strong winds prevailed. No sooner did he arrive in the mountain climate than a relapse took place; the fever taking the quotidian form, and the attack being very severe. Quinine seemed to have no effect, and the heat-producing power was so low, that no clothing or bedding seemed sufficient.

The patient complained, that he never felt warm but when in the hot stage of the fever, and that he could do nothing but sit before the fire, and put on more wood. At the end of a week, as there was no improvement, I sent this officer down to a sheltered valley, some 4000 feet below; no sooner did he arrive there, than an improvement took place, and in a few days the fever left him entirely; although the valley is by no means free from "malaria," the inhabitants often suffering severely from remittents and intermittents.

In this case the effects of change of temperature, from heat to cold, and from cold to comparative heat, were most distinct, and showed beyond all doubt, that the beneficial effect of change of climate, in cases of malarious fever, is not owing to removal from the presence of any poison; or to the killing effect of cold, upon any germs or growths; but to the influence upon the system of an invigorating climate, which a very cold one is not, when the heat-producing power is low.

CHAPTER XIX.

MALARIA IN CONNECTION WITH ACCLIMATISATION AND THE ALLEGED IMMUNITY OF CERTAIN RACES FROM ITS EFFECTS.

New arrivals in hot climates sometimes suffer more from disease than natives or or old residents—The reason explained—Opinions of M. Boudin and Sir J. R. Martin—Under equal circumstances of exposure, tendency to malarious disease increases with length of residence in hot climates—Each attack of fever increases the liability to a recurrence—Owing to a change in constitution, after a certain period heat is borne with less distress, but susceptibility to cold increases—New arrivals more subject to ardent fevers, and old residents to intermittent and remittent—Instances—Dark races affected by unusual heat—Neither in black nor in white men does the constitution ever become malaria proof—Each race suffers least in the climate for which it is most fitted—Precautions taken by certain tribes exempt them in some degree from malarious disease—Negro race said to be proof against malaria—Fergusson's remarks—Immunity of the Negro comparative only, and limited to hot and equable climates—Observations of Drs. Merrill and Reyburne—Malarious disease in the lower animals.

It has been observed, that in a hot climate, new arrivals are sometimes more readily affected with disease, than the natives, or those long resident. This has been ascribed to the constitutions of the latter having become malaria-proof,—to the poison having lost its power.

The Portuguese in Africa, as Lind tells us, endeavoured to bring about this desirable condition by frequent bleedings, and by imitating the diet of the natives,* (as we are sometimes advised to do in India,) in order to get rid of their own blood, and supply its place with that of an acclimatised description. The result was, in too many cases, very different from that which was intended.

The fact is, that old residents do not become malaria-proof. But, as in the case of the East India Company's army, the apparent result of acclimatisation is mainly owing to the local knowledge acquired by experience, and to the precautions consequently taken against exposure to climatic vicissitudes.

M. Boudin observes, that the fact, of the proportion of

* *On the Preservation of Health of Europeans in Hot Climates*, p. 4.

those attacked with malarious fever increasing with length of residence, is proof of the impossibility of acclimatisation.*

The observations of Sir A. Tulloch, and others already quoted, show that mere length of residence in an unhealthy region, confers no immunity from the effect of malaria, and all Indian experience tends to the same conclusion.

Sir J. R. Martin says: "All statistical observations go to disprove anything like acclimatisation, in the East Indies. On the contrary, the disposition to disease and death increases by length of service and age."†

The fact, that each attack of malarious fever, increases the predisposition to a recurrence of the disease, is in itself tolerably conclusive against the possibility of the constitution becoming malaria proof.

No doubt, the constitution does undergo a change, when it has been for some time inured to a high temperature, so that heat is borne with less distress, and cold is more acutely felt; the heat-generating power becoming less active. This is seen in the distress which is felt on the sudden setting in of hot weather gradually diminishing as the heat continues; and is also shown by white men, on their first arrival in a hot climate, being very liable to ardent fevers, which are caused by heat; while after longer residence, they become more subject to those of remittent and intermittent type, which are the result of chill. Thus it was observed at Hong Kong, that "the men who last year suffered chiefly from continued fever, have, since the climate has had time to affect them, had intermittent and remittent fevers."‡

Again, the 49th Regiment landed in Bombay from England in October 1865, and was immediately sent to Deesa, a very hot station, where it suffered very severely from continued fever. The following year also the Regiment, at the same station, suffered from the same form of disease. But in

* *Traité de Geographie et de Statistique Medicales*, ii. 150.

† *Report of Royal Commission on Army in India*, i. 6.

‡ *Parliamentary Report, China*, 1866. p. 292.

1867, the official report states: "In the Northern (Division) the great prevalence of *paroxysmal* fevers was in the Royal Artillery at Ahmedabad, and the 49th Regiment at Deesa. The latter corps, which had a remarkably high proportion of cases of continued fever, at the same station, in the preceding year, returned only three cases of that type, during year under review."*

The constitutional change, above alluded to, is accompanied however by a continually-increasing depression of the vital powers; the effect of long residence in a hot climate being, as already shown, to increase the sensitiveness to any fall of temperature and, in the white race, to produce a low state of vitality; thus rendering the system extremely liable to attacks of disease.

Even in the dark races, previous exposure to an unaccustomed degree of heat increases the susceptibility to malarious fevers, on subsequent exposure to chill; as is seen sometimes in India, on the removal of native troops from a very hot district to one which is cooler.

Thus at the station of Bangalore, it has been observed, that native troops are particularly liable to fever, especially on their first arrival; and more particularly those coming from the western coast or Carnatic, where the climate is much hotter and more equable.

Bangalore is 3000 feet above the sea, the station and neighbourhood are remarkably free from all supposed sources of "malaria," and, for the white soldier, it is one of the healthiest stations in India; so healthy indeed, that an official report states: "The statistics of the troops stationed at Bangalore, the next largest European station in the command, bear sufficient evidence of the high standard of health they enjoyed, in the salubrious climate of this delightful cantonment."†

"Malaria" then cannot be blamed, for the prevalence of fevers amongst the native troops at this station.

* *Army Med. Reports*, 1865, 1867.
† *Army Medical Report*, 1866.

Further, we are told that "the cause of this fever does not appear to be connected with the locality of the "lines"* for none of the four native infantry "lines" have ever been exempted from fever, on the arrival of a corps from the Carnatic, or a warmer climate."†

"The 27th N. I. arrived at Bangalore from Palaveram, in March 1834. Soon after, fever appeared amongst them; a part of the Regiment was detached to French Rocks, and Mysore, and both detachments suffered equally with the head quarters at Bangalore."†

"The sickness which has occurred in the 32nd N. I. lately arrived, and occupying the lines of the 4th N. I. who had left in a healthy state, may be adduced as another instance of the peculiarity of the constitution of men, arriving in this division from the low country, being unsuited to the Mysore division, till it has become habituated to it. The fever this corps has suffered from, was the bilious remittent or jungle fever."‡

The liability of the sepoy to malarious fever at this cantonment still remains, and so does the healthy condition of the white soldier, at the same place.

Dr. McPherson, Depnty Inspector General, writes, in 1860: "Bangalore cannot be said to be a healthy station for the native soldier who has just come to reside there. Indeed the same remark is applicable to the whole Mysore plateau, so far as the natives are concerned. They are prone to attacks of fever more especially if they have come from beyond sea, or from a coast station."§

Here then, we have an example of a succession of regiments of native troops suffering severely from malarious fever, when quartered in different localities, at a station which is remarkably free from supposed sources of malaria; but which is high, exposed to strong winds, and has a climate much cooler, and variations of tempera-

* Lines of Huts.

† *Madras Topographical Reports*, 1844.

‡ *Ibid.*

§ *Report of Royal Commission on Sanitary state of Army in India*, ii. 630.

ture much greater, than those of the districts of which the sepoys were natives, or in which they had been previously cantoned: those men who had previously been quartered in the hottest stations suffering most. Yet, at this very time, the white troops at the same place were enjoying excellent health.

It is not then owing to their constitution having become malaria-proof, that the sepoys are enabled to withstand the malaria of the plains, so much better than white troops. If the soil, so to speak, had been exhausted by the poison, no mere change of locality or of climate could break the charm. The sepoy, proof against the "malaria" of the Carnatic, should also be proof against the "malaria" of Mysore. Again unless we are to suppose that there is a black and a white "poison," the native of the plains of India should not suffer as he does from fevers, in the Himalayah and in other elevated regions of his own country, while the white man, who suffers so severely in the plains, is there enjoying excellent health.

The natives of a country, however, do not become proof against the malaria even of their own locality. The negroes suffer from fever in Africa in their own homes, and that very severely, as Livingstone shows;* while in India, the whole population of large districts is often prostrated by the same disease. Strangers, however, accustomed and adapted to a different climate, often suffer much more than the natives; and all circumstances of exposure being the same, they suffer in proportion as the climate differs from that to which they have been accustomed, or for which they are by nature adapted. Thus the native of India, fitted for a hot climate, enjoys a high degree of health in the hot season, which is so fatal to the white man; but in the cold season, the white man often suffers less from malarious disease than the native. In the epidemic fever of last cold season in upper India, the sickness and mortality were chiefly amongst the natives; the proportion of Europeans attacked being comparatively small, and the mortality amongst them trifling.

* *Travels in Southern Africa*, 249, 480, 495.

At Hong Kong in 1865, when the white troops suffered very severely from malarious fevers especially in the hot season, the Gun Lascars (natives of India attached to the Artillery) suffered little, and the official report states: "The Lascar company enjoy better health in the hot season than in the cold."*

The lofty Eastern Ghats, exposed to strong winds and heavy rains, are extremely feverish, and almost uninhabitable by the natives of the coast; yet the hill people are a sturdy race.†

Major General Cotton observes, that the natives of Malabar cannot live in safety, in what we consider the most healthy climate of the Neilgherries; while the people of Mysore and Coimbatore do as well there as Europeans.‡ The climate of Malabar, it should be observed, is hot and equable, and that of the elevated districts of Mysore and Coimbatore, cooler and more variable.

Even in Europe, the cause of malarious fevers acts differently upon those adapted to different climates. Thus Cleghorne observed, that though the English suffered severely from the summer fevers at Minorca, they suffered less than did the Spaniards from the winter fevers; the winds then being cold and piercing.§

Thus the greater freedom of the natives of hot climates from those forms of malarious disease, which are so fatal to strangers, is not owing to the constitutions of the former being proof against malaria, but owing to those of the latter being unfitted for the climate, and therefore more liable to be affected by disease.

The ability of certain races to exist in regions which are deadly to others, whose constitutions are adapted to a different climate, has led to the idea, that certain tribes are insusceptible to malarious influence.

The Coles, Gonds, and other tribes, in India, certainly

* *Parliamentary Report, China*, 1866. 293, 294.

† *Madras Topographical Reports*, 1844.

‡ *Report Royal Commission on Sanitary State of Army in India.* i. 127.

§ *Diseases of Minorca*, 258.

inhabit jungles in which, at certain seasons, "malaria" is intense; but all suffer severely from fevers, notwithstanding the experience which has taught them to avoid the most deadly places. The same thing may be observed of all tribes inhabiting similar regions. No race has yet been discovered, which is proof against malarious disease; though all do not suffer alike in the same climate.

Besides natural adaptation to different degrees of heat and cold, precautions learnt by long experience contribute much to the comparative immunity of tribes inhabiting malarious districts. Thus it is with the Jeevas of the Punjab, a tribe who, employed in fishing and catching wild fowl, spend a great part of their lives in wet and marshy spots; constantly passing their nights in the "jheels" and swamps.

These men are a hardy race, and show no sign of paludal cachexia. When not engaged in fishing, they are chiefly employed in carrying heavy loads on their shoulders, by means of a "banghy,"* an occupation which involves great muscular exertion. The Jeevas have no belief in any exemption of their race from fevers or dysentery; yet they contrive to secure themselves against the attacks of "malaria." These people wear no veil nor respirator, and take no pains to avoid the inhalation of poisonous germs, or miasmata; they do not even avoid drinking marsh water; but their whole energies are directed to the protection of their bodies from the nightly chill.

The costume of the Jeeva, which he always dons at sunset, is quite different to anything worn by the other people of the country; it consists of a large thick wadded coat, which envelopes him from head to foot. Wrapped in this garment, and with a smouldering fire in his boat, the Jeeva paddles out towards the centre of the swamp; and there, bending down the tall reeds to form a roof, he spends the night in watching his snares and nets, unharmed in the midst of "malaria."

* A piece of tough wood from 6 to 8 feet long to each end of which a portion of the load is suspended.

It is not to be supposed that precautions, which are found sufficient to protect the native of a tropical country in his own home, from malarious disease, will always be sufficient to protect white men, whose vital powers are already struggling against the deadly influence of a hostile climate. But they may serve to indicate the direction from which danger is to be expected.

With regard to the negro race, one of those supposed to be proof against "malaria," Fergusson observes: "The adaptation of the negro to live in the unwholesome localities of the torrid zone, that prove so fatal to Europeans, is most happy and singular. From peculiarity of idiosyncrasy he appears to be proof against fevers; for to him marsh miasmata are in fact no poison, and hence his incalculable value as a soldier, for field service in the West Indies. The warm, moist, low, and leeward situations, where these pernicious exhalations are generated and concentrated, prove to him congenial in every respect. He delights in them, for he there enjoys life and health, as much as his feelings are abhorrent to the currents of wind that sweep the mountain tops; where alone the whites find security against endemic fevers. One of the most obvious peculiarities of the negro as compared with the European is his thick oily skin, rank to a degree; and from this circumstance the theorist, when he speculates upon the mode of reception of the marsh poison into the constitution, whether by lungs, stomach, or skin, may draw a plausible conjecture in favour of the last."*

It is possible, that the skin of the negro does, from its thickness and oiliness, help to protect him from malarious disease; and we know that in his native country he endeavours to heighten these conditions, which are calculated to afford so much protection from sudden variations of temperature, by anointing himself liberally with grease. This is not done, however, with any view of preventing the ab-

* *On the Nature and History of the Marsh Poison.* Trans. Roy. Society Edin. Vol. ix.

sorption of a specific poison; but, as Livingstone tells us, to prevent evaporation from the surface of the body; in a word, to prevent chill.

The negro is not proof against "malaria," when he is exposed to cold and wet, even in his own country. The men who accompanied Speke and Grant from the low, moist, hot coast of Zanzibar, and who being unclothed were very susceptible to climatic variations, were all attacked with fever on penetrating into the interior; where the country was higher and the variations of temperature greater, and they were exposed to heavy rain. The natives who accompanied Livingstone also suffered severely from the disease, under similar circumstances.

The fact is, that negroes are adapted to endure extremes of heat; it is in the hottest regions that they enjoy the highest degree of health; and it is in the same regions therefore, that they suffer least from malarious disease.

In the moist and sultry climate of the West Indies, the negro thrives. On the hot and steamy shores of his native Africa, he of course flourishes; in fact, the more intensely hot the climate, and consequently the more deadly to the white race, the better does it suit the negro. Transferred to a cooler climate however, the African loses his advantage over the white man; the liability to malarious disease becomes equalised and something more.

In the United States of America, the black race suffers very severely from malarious disease.

Merrill, speaking of malarious fever complicated with pneumonia, amongst the negroes in the United States, says: "Few diseases are more fatal to the negro, in whom the vital powers are less energetic than in the white subject; and the sinking stage of malignant disease proportionately more rapid."*

Reverse the picture, and what could be more applicable to the state of the white man, in tropical Africa?

Dr. R. Reyburne, in his remarks upon the diseases of the

* *On Fevers*, 173.

freed slaves, in the United States, expresses his entire disbelief in any exemption of the negro from malarious disease; his observations however relate to a comparatively cold climate.

This writer states, that in Northern Virginia and Maryland, amongst 50,000 freed people, of whom 52 per cent were full-blooded Africans, 2776 cases of remittent and intermittent fever were treated, from June to December 1865; being 35 per cent of the total sickness.

The same writer quotes from the report of the surgeon in chief of the freedman's bureau of South Carolina, for September of that year, that the cases of malarious fever, in the district named, amounted to 40 per cent of the disease amongst the freed slaves; and he mentions, that in Virginia the proportion of this disease in the month of October, was nearly 56 per cent, and in Georgia, during the same period, nearly 33 per cent of the aggregate sickness amongst the same class.*

Compared with the prevalence of the same diseases amongst the whites, this contrasts very strongly with what is observed on the coast of Africa, in the West Indies, and elsewhere in the tropics.

It is evident, that the negro's comparative safety from malarious disease depends upon the heat and equability of the climate; and is not owing to either his constitution or his skin being proof against the absorption of a specific poison.

In connection with this subject, it is interesting to observe that the negro, after a lengthened residence in a cooler climate, becomes more susceptible to the diseases of the tropics.

The Negroes, who went out from England with the Niger expedition, suffered much less from fevers than the white men, but very much more than their countrymen, who had never left the coast.†

The lower animals are not exempt from malarious disease;

* *American Journal of Medical Science*, April, 1866.

† McWilliam, *Niger Expedition*, 180.

and in them, as in man, it follows exposure to climatic vicissitudes.

During the great epidemic of malarious fever in Southern India in 1810, which has been already alluded to, the mortality amongst the cattle, in the affected districts, was very great. The same thing has been observed in other outbreaks of this disease.

Fergusson speaks of the blind terror of the Portuguese, which led them to remove the king's hunting stud from the Alemtejo during the malaria season, lest the horses should die of fever;* but the precaution was by no means a useless one.

I have already referred to the mortality, which occurred amongst the horses of a detachment of Native Indian Cavalry stationed in the Hadoda pass in Abyssinia, at the time that the men were suffering very severely from fever and dysentery. In 1862, when malarious disease was rife in Mooltan and the neighbouring district, most of the mail-cart horses on the road between that place and Lahore died from fever.

Dr. H. Falconer mentions, that great numbers of cattle die from fever in the Terai, and that enlarged spleen and anæmia are very common amongst them.†

Monfalcon mentions several instances of the occurrence of great mortality amongst sheep and cattle in marshy localities, during or following periods of great heat. This writer also mentions that cattle in such localities are very subject to thoracic and bowel affections.‡

Many other writers have made similar observations.

In most hot countries, the lower animals require careful protection from nightly chill, during the seasons in which "malaria" is most dangerous to the human race; and in Upper India, where the variations of temperature are great, a horse or bullock, if of any value, is often better clothed at night than his master. However poor a native may be,

* *On the Nature and History of the Marsh Poison.* Trans. Royal Society of Edin. Vol. ix.

† *Report of Roy. Commission on Sanitary State of Army in India.* i. 308.

‡ *Hist. Med. des Marais.* 503–4.

and however little clothing he may have for himself, he always does the best he can to guard his cattle from the cold at night; and this, not out of any regard for the comfort of the animals, but to save their lives.

CHAPTER XX.

DISEASES RELATED TO MALARIOUS FEVERS.

Close connection between malarious fevers and dysentery, hepatitis, pneumonia and other diseases has been hitherto mysterious—Observations of Pringle, McGrigor. Jackson, Cleghorne, Annesley, Williams, Parkes, Haspel, McLean, and Morehead, on the connection between dysentery and fever—Also of McLean, Bird, Martin, Morehead, and Haspel, on hepatitis and its causes—Each of these diseases occurs in connection with malarious fevers at the same time, in the same place, and in the same person—Rheumatism and thoracic affections often associated with malarious fevers—Latter very frequent in cold seasons—Observations of Davis, Cleghorne, Merrill, and Morehead—The diseases most commonly associated with malarious fevers are such as arise from climatic causes.

From the explanation which has been given, of the nature and cause of malaria, it is easy to understand the intimate, but hitherto mysterious, connection between malarious fevers and dysentery, hepatitis, pneumonia, rheumatism, and other diseases which are admittedly caused by climatic influences.

Dysentery is so inseparably connected with malarious fever, especially in hot climates, that it is frequently described as a malarious disease.

Pringle says: "Hitherto, we have seen how similar are the causes, of the remitting and intermitting fevers, and of the bloody flux. Nay, the affinity extends to the occasional or exciting causes. For in the end of summer, or in autumn, when any number of men are exposed to night damps and fogs, especially after a hot day; or lie upon wet ground, or in their wet clothes; part of them will be seized with that kind of fever, and part with this flux, and perhaps some of them will have a disease compounded of both."* The close connection between these disorders was observed at Walcheren, in Burmah, and in China; and it is often seen in India. McGrigor mentions the diseases referred to, as constantly complicating the fevers of the army in Egypt, and says that

* *On Diseases of the Army*, iii. 6. 253.

in the 10th Regiment, which suffered very severely from fever in the desert, "every case ended in dysentery or hepatitis."*

Robert Jackson observes, of the fevers which occurred during the American war: "Indeed the intermittent, the dysentery, and even the dropsical swellings, so alternated with one another, as evidently showed that they all depended upon the same general cause."†

"Sometimes," says Cleghorne, "a tertian is changed into a dysentery, or a dysentery becomes a tertian."‡

Blane says of fever and dysentery: "The two diseases may be considered vicarious."§

Annesley considers that dysentery is the result of malaria, and that "this is unequivocally proved by its prevalence where, and in seasons when, malaria and vegeto-animal miasmata abound."‖

Dr. Williams observes: "The connection between intermittent fever and dysentery is so intimate, that of a given number of persons exposed to the action of paludal miasmata, as a boat's crew sent on shore in a tropical climate, the probabilities are, that on the men returning on board, part will be seized with dysentery and part with remittent."¶

Again, the same writer says: "It seems then distinctly proved that dysentery and paludal fever equally originate in low and marshy districts, that they both equally disappear in proportion to the improved drainage of those districts, and also that they frequently coexist, or else alternate in the same person; and consequently it follows that dysentery is a disease of a specific nature, and originates in some peculiar modification of the paludal poison."**

Dr. Parkes notices the frequent association of dysentery with remittent and intermittent fevers."††

* *Medical Sketches of Army in Egypt*, 59.
† *On Fevers*. 303.
‡ *The Diseases of Minorca*. 134.
§ *Diseases of Seamen*. 449.
‖ *On Diseases of India, &c.* i. 85.
¶ *On Morbid Poisons*. 540.
** *Ibid*. 542.
†† *On Dysentery and Hepatitis of India*, 126.

"It may be stated as a general proposition" says Dr. Aitken "that there is no country where paludal fever exists, in which dysentery is not an endemic and prevailing disease."*

M. Haspel considers both dysentery and hepatitis to be caused by malaria.†

The Royal Commission reports, that "next to fevers in frequency, but more fatal, comes the dysentery of India. In its causes, it is intimately associated with tropical fevers, remittent and intermittent; so much so, that where fevers are present, dysentery is never far off."‡

Dr. Maclean mentions the case of a young coffee planter from the south of India, who, with two companions, went on a shooting excursion into a jungle, during the malaria season; when one of the party was attacked by dysentery, "in a severe, and probably malarial form," another suffered from remittent fever, and the third had an attack of hepatitis of a low type, ending in abscess.§ This case shows very clearly the common origin of the three diseases, and the instance of the 10th Regiment in Egypt does the same. Indeed for two of these affections to appear at the same time, in the same individual, is of frequent occurrence. I have met with many cases of dysentery combined with intermittent or remittent fever, and have seldom seen a case of hepatic abscess unaccompanied by dysentery.

That dysentery is caused by exposure to damp and cold is almost universally admitted in India. Dr. Morehead observes: "When intermittent and remittent fever co-exist with dysentery, it will probably always appear that the conditions of malaria co-exist with a damp and variable atmosphere. But, according to my belief, malaria causes the fever, and the cold damp air the dysentery; hence we can understand why the two affections may sometimes be associated, but also be frequently distinct."‖

* *Science and Practice of Medicine*, i. 618.

† *Maladies de l'Algerie.* Tom. i. 40, 45.

‡ *Report of Royal Commission on Sanitary State of the Army in India*, xiv.

§ *Army Medical Report*, 1865.

‖ *On Disease in India*, xiv. 277.

From what I have already shown, it is pretty clear that chill is the cause of both diseases.

Neither fever nor dysentery is confined to damp or marshy places; both being common in India, at stations remarkable for drought and barrenness, such as Jhansi and Mean Meer. The worst cases of dysentery I have ever seen, occurred at the former station, and were most of them complicated with hepatic abscess.

Dr. J. Bird says: "At Belgaum, elevated more than 2000 feet, liver disease was very prevalent during the cold, dry, easterly winds of the cold months; and both pure liver disease, and that accompanying dysentery, are produced by the predisposition, caused by high temperature, followed by cold."*

"At Bangalore, hepatitis is by no means so common amongst those who avoid exposure, especially at night; and women and children very seldom suffer from it."†

Sir J. R. Martin observes: "Liver disease and dysentery are continually associated with each other, so far as to be a most marked point of observation with all medical officers, in the East Indies especially."‡

Again, in reply to a question as to whether soldiers should wear flannel night and day, Sir J. R. Martin says: "Most assuredly; for the diseases of India are, in a large measure, contracted by exposure during sleep. I may mention one station, and that an eminently healthy one, Bangalore, where a soldier upon lying down and falling asleep, in hot weather or during the rains, in a state of profuse perspiration, suffers from a sudden change of wind, or a cold gust from the mountains; and he rises with a shivering fit, and with acute inflammation of the liver. A flannel shirt there, would be a great protection."§

Dr. Morehead says: "Is hepatitis with a liability to suppuration, peculiarly related to cachexia, engendered by the

* *Report of Royal Commission on Army in India.* i. 221.

† *Madras Topographical Reports.* 1844.

‡ *Report of Royal Commission on Sanitary State of Army in India,* i. 4.

§ *Ibid.*

prolonged influence of an elevated temperature? I believe that it is so. It is very probable that future research will show, that the exhausted and enfeebled by continued heat, and its associated debilitating conditions, are very prone to hepatitis, and that in such individuals, the inflammation is very frequently excited by exposure to external cold,—I mean to such depression of temperature, as suffices to influence bodies whose power of generating heat is low."*

Thus we see that malarious fevers, dysentery, and hepatitis may appear at the same time, and under the same circumstances of exposure; and that any two of them may appear at once in the same individual.

M. Haspel observes: "This frequent association of intermittent fevers with dysentery and affections of the liver, the transformation of these three morbid states one into the other, and their alternate succession, are these not proofs that they depend upon the same cause? One cannot refuse to recognise between these maladies so unlike in appearance, a very great affinity, points of contact intimate and numerous, and in short a family connection."†

Rheumatism is not unfrequently associated with malarious fevers. In Africa this has been particularly noticed; and in India, as Annesley observes, "this complication is very frequent amongst the natives of the climate and old European residents."‡

In cool climates, or in the cold season of hotter climates, thoracic diseases are very frequent complications of malarious fever.

"One of the most frequent complications of the protracted fevers of Walcheren, was inflammation of the lungs, an affection that became very frequent in November, and that generally ended fatally."§

Cleghorne observes, that in Minorca: "The summer fevers are generally complicated with fluxes, and painful complica-

* *On Disease in India.* xv. 363.
† *Maladies de l'Algerie.* Tom. i. 86, 87.
‡ *On Diseases of India, &c.* vol. ii. 451.
§ Davis, *On the Fever of Walcheren*, 43.

tions of the chylopoetic viscera; and those of winter with coughs and catarrhs, pleurisy, pneumonia, pericarditis, &c."*

Merrill says, that in the United States, malarious fever complicated with pneumonia, sometimes became epidemic, among the negros on large plantations; often extending to several plantations in the same neighbourhood, proving exceedingly violent and fatal.†

In India, especially in the cold season, malarious fevers are frequently complicated with bronchitis, pneumonia, and pleurisy; and these thoracic complications are more common amongst the natives than amongst the whites; chiefly perhaps because the latter are generally better clothed and sheltered, possibly also in some degree from the influence of race.

Pleuro-pneumonia was a very general complication of the fevers of last Autumn in Upper India amongst the native population.

Dr. Morehead observes: "Bronchitis is a common accompaniment of remittent fever, in the natives of India; and in the Jamsetjee Jejeebhoy hospital at Bombay, pneumonia is the most usual of all the inflammatory complications, in asthenic subjects."‡

The same authority says: "These affections do not frequently complicate remittent fever, in Europeans in India."‡

This confirms what I have already observed on the same subject; but, Dr. Morehead quotes Dr. R. H. Hunter's medical history of the Queen's Royal Regiment, during the Afghan Campaign of 1838-9, that in the colder climate of Afghanistan &c. in the winter months, pneumonia was a frequent complication of remittent fever amongst the white troops.‡ The men referred to had of course previously served in the hotter region of Hindostan.

Even in the south of India, thoracic complications are frequent in malarious fevers in the cold season, and especially in the more elevated districts. For instance at Palghat,

* *Diseases of Minorca*, 259.
† *On Fevers*, 173.
‡ *On Disease in India.* v. 73.

"fever of an irregular quotidian type, and not unfrequently complicated with affections of the chest, is common in December and the beginning of January."†

Thus it may be seen, that whether in hot or in cold, in wet or in dry climates, the affections which accompany, and are intimately connected with malarious fevers, (some of them so intimately, that they have themselves been ascribed to "malaria,") are those which are almost universally admitted to arise from exposure to chill.

From what I have already shown, there can be no doubt, that these diseases, and the fevers with which they are so constantly associated, have a common origin in climatic vicissitudes.

† *Madras Topographical Reports*, 1843.

CHAPTER XXI.

CONCLUSION.

To sum up briefly the contents of these pages. It has been shown:—

1. That exposure at night in a malarious locality necessarily involves exposure to chill.

2. That all the effects produced by so called "malarious influence" may be caused, by the rapid abstraction of animal heat, without the intervention of any specific poison.

3. That exposure to chill is admittedly the cause of the diseases, which are constantly associated with malarious fevers; as well as of the recurrent attacks, or so called "relapses," of the fevers themselves.

4. That the effect of continued exposure to a high temperature is, at once, to diminish the heat-generating powers of the system, and to increase the susceptibility to malarious fever; as well as to aggravate the intensity of the disease.

Under all these circumstances, it appears impossible to arrive at any other conclusion, than that malaria is chill.

The nature and cause of "malarious influence" being determined, the principles to be followed in any measures for the prevention of the diseases resulting from it, require but little demonstration, and may be summed up in a few words, viz.

1. That the predisposing influence of excessive and continuous heat is, as much as possible, to be avoided.

2. That the greatest care is to be taken, in malarious localities, to protect the body from cold.

3. That when, (as so often happens in tropical countries, and from the exigencies of military service,) exposure to great heat is unavoidable; its predisposing effects may, and should, be in a considerable degree counteracted by frequent temporary removals to a cooler climate.

4. That the greater the degree of heat, and the longer and more continuous the exposure to it, the more vitally important

does it become, that even a slight degree of chill should be avoided.

By the observance of these principles, instead of futile precautions against an imaginary poison, much may be done to diminish the great prevalence of disease in all malarious countries; and especially to abate the sickness and mortality, which is so rife amongst white men, in tropical regions.

It may perhaps appear scarcely necessary to add, that when men are struggling for life, in a climate for which their organisation is wholly unfitted, it is necessary either for the cure of disease or for the preservation of such health as remains to them, that every means, medical and hygienic, should be carefully directed to the support of the vital powers; and that all measures which tend to reduce those powers should be studiously avoided.

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